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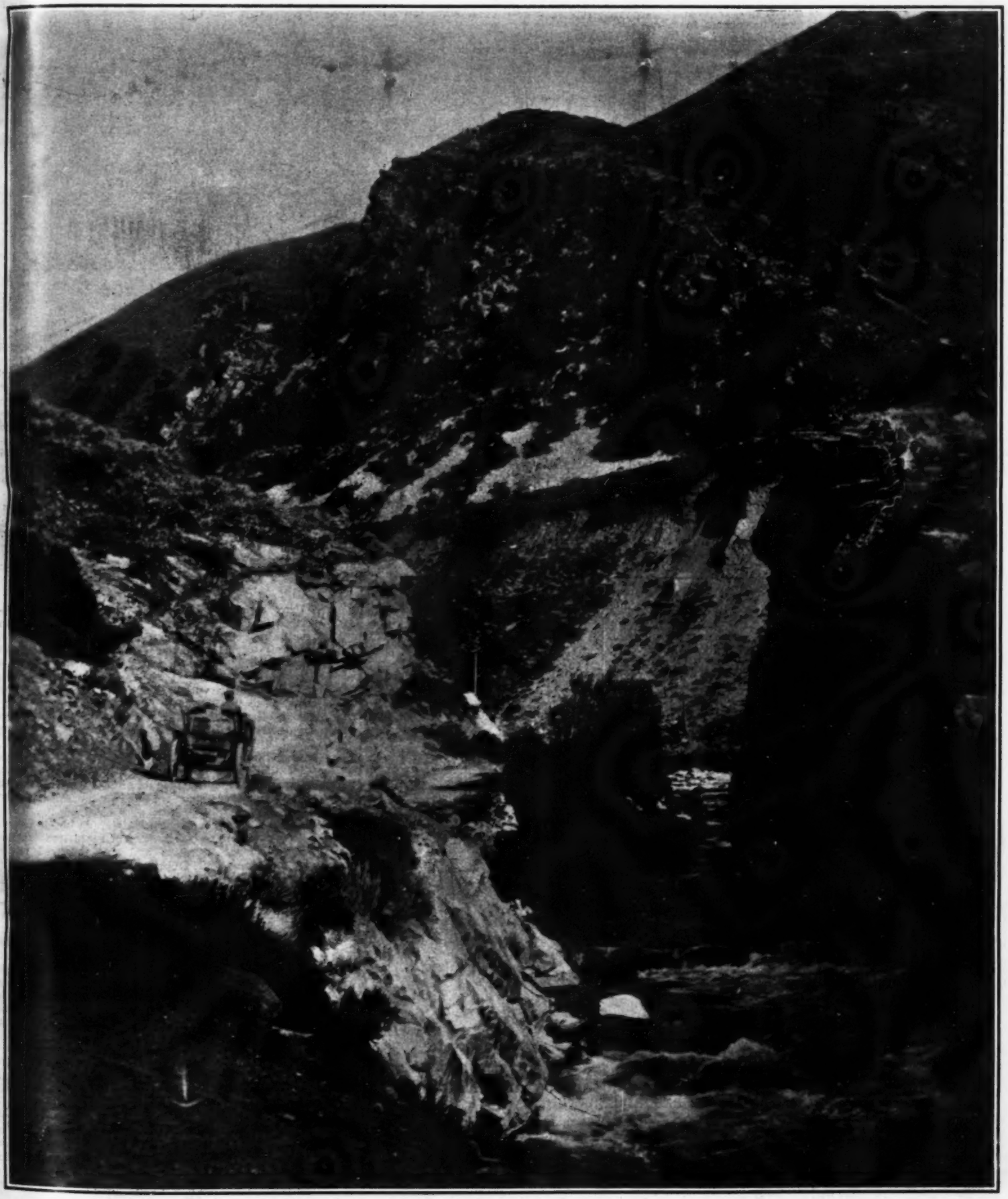


THE RECORD-BREAKING TRANSCONTINENTAL FRANKLIN TOURING CAR PASSING THROUGH WEBER CANYON, UTAH, IN THE HEART OF THE ROCKY MOUNTAINS.

This machine, which is a 30-horse-power, 6-cylinder air-cooled car, cut in two the previous 33-day record made in 1904 by a 12-horse-power, 4-cylinder Franklin. It covered the 4,000 miles between San Francisco and New York in 15 days, 2 hours and 12 minutes elapsed time, or at an average speed of 10¼ miles an hour actual running time.

A NEW TRANSCONTINENTAL AUTOMOBILE RECORD.

THE record run of thirty-three days across the continent, made by a Franklin 12-horse-power, four-cylinder, air-cooled runabout in 1904, has been cut in half recently by a 30-horse-power six-cylinder car of the same make, which made the run of nearly 4,000 miles in 15 days, 2 hours, and 12 minutes elapsed time. This car was driven the greater part of the distance by L. L. Whitman and C. S. Carris—the same gentlemen who made the record run before. The car left San Francisco at 6 P. M. on August 2, and reached New York at 11:12 P. M. on August 17. When the allowance of three hours is made for the difference in time of the two cities, the total elapsed time was found to be that given above. Throughout the trip the car was operated continuously night and day, an extra driver and mechanic being employed to relieve Whitman and Carris, and during some parts of the trip a fifth person being taken along to act as guide. For a considerable distance the car carried four passengers in addition to its dead load and several thousand miles were also traveled carrying three passengers. The total weight of the car and its load, including the driver and mechanic, was about 3,200 pounds. The car was fitted in front with 36 x 3½ inch tires, and at the rear with 36 x 4 inch tires. Its tread was 54 inches, and its wheel base 120. It had the same three-speed and reverse sliding gear transmission that is used in the regular six-cylinder tonneau, the weight of which car, complete, is 2,500 pounds. About 400 pounds of the dead load carried consisted of repair parts, an ax, shovel, pry poles, extra supplies of gasoline and oil, tires, and wearing apparel for use at night, etc. The total weight of the car loaded was about equivalent to the weight of the six-cylinder touring car when loaded. The maximum speed of this latter car is about 50 miles an hour. Throughout the transcontinental trip the special touring runabout, which was fitted with ordinary pneumatic tires having no special devices for use in crossing the sandy deserts, averaged 16 1-3 miles per hour. At times it made only three or four miles an hour, while at other places where the roads were good, it nearly equaled its maximum speed. Thirty-six hours were lost between Chicago and New York, owing to the car running off the road at a sharp turn while speeding at the rate of 25 miles an hour. This accident occurred in a dense fog. The car was damaged considerably, but repairs were made and the trip was eventually finished. In the run of 600 miles across the Nevada desert and Ogden, an average speed of 11 miles an hour was made. Ogden was reached in 4 days as against 10 in 1904; and had it not been for the mud in Nebraska and Iowa, Chicago would have been reached inside of 8 days. As it was, 11 were required. The trip from coast to coast was laid out on a 10-day basis, and, but for the bad weather conditions and the accident, the tourists would have come very close to maintaining their schedule.

The touring runabout shown was equipped with a 20-gallon gasoline tank, and a 1-gallon tank for lubricating oil. The average fuel consumption throughout the trip was 12 miles per gallon and the consumption of oil was 100 miles per gallon. The six-cylinder engine is similar in every respect to the regular four-cylinder engine, which we have illustrated at various times. The cylinders have a bore and stroke of 4 inches and a compression of 62 pounds to the square inch was employed. The inlet valves and both the main and the auxiliary exhaust valves are 1½ inches in diameter. All valves are mechanically operated. The auxiliary exhaust valves, shown at the base of the cylinders, open when the pistons reach their lowest points and allow the greater part of the burned gases to escape immediately. The remaining gases are expelled from the main exhaust valves in the ordinary manner. To this auxiliary exhaust and to the fan in front, which also tends to cool the cylinders, as well as to the fan blades in the flywheel, is laid the successful operation of this engine. The engine was found to operate perfectly in the cool mountain atmosphere at elevations up to 8,000 feet, or in the hot desert air where the temperature stood at 120 deg. F.

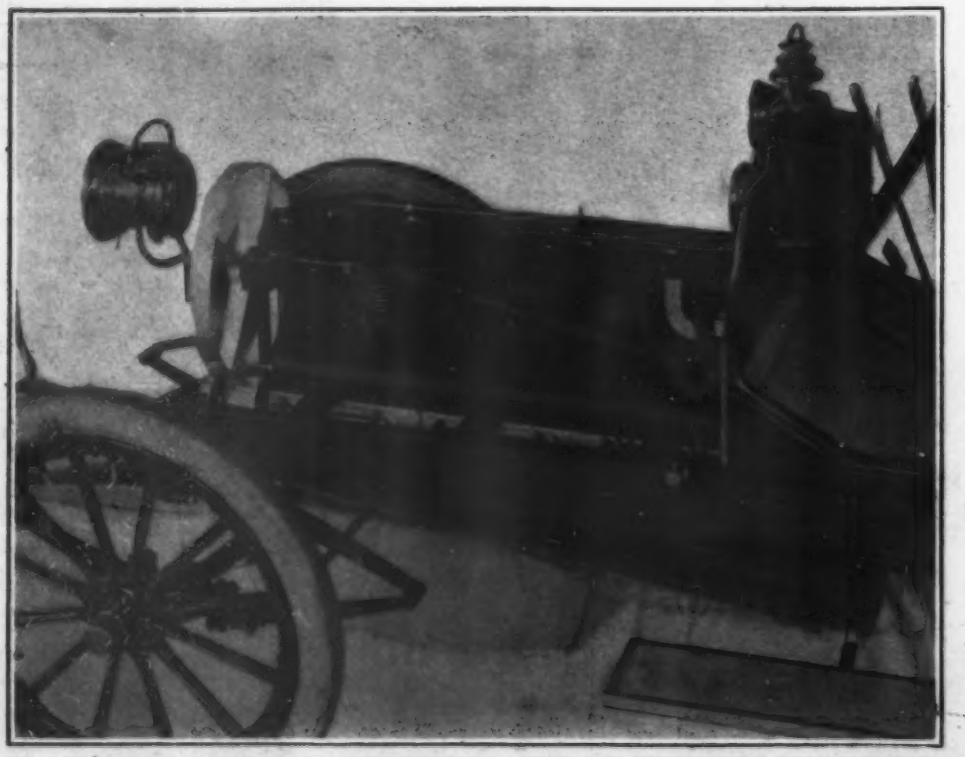
The engine is mounted on an aluminium base and is oiled by splash lubrication, the oil level being maintained in the crank case by means of a mechanical oiler. The engine makes 3¼ revolutions to one of the rear axle on the high speed, 4.88 to one on the intermediate speed, and 11.7 to one on the low gear. The reverse gives a reduction of 14 to 1. The rear axle is of the floating type and is mounted on annular ball bearings. The drive is by means of propeller shaft and bevel gears. The motor is rated at 30 horse-power at 1,500 R. P. M.

Our illustrations show some of the conditions which the car encountered during the trip. These conditions were even more severe than those met with in 1904. In many places the roads were well-nigh impassable. Numerous streams had to be forded and several times the car was almost completely submerged. Hundreds of miles were covered at a temperature of 120 degrees. The car climbed the Rocky Mountains in almost as good time as is made by the "Overland Limited," the fastest railway train running across the continent. The highest elevation reached was 8,000 feet at Sherman, Wyo. Thirty miles were traveled over a railroad track in four hours, and throughout the hardest part of the trip one run of 300 miles was made without even lifting the bonnet. The engine operated throughout the trip with scarcely any trouble, and not more than two or three hours were consumed in making adjustments throughout the whole 4,000 miles. In Iowa the car was preceded by a furious rainstorm which made the roads almost impassable.

The new record is one of which the manufacturers of the Franklin car may well be proud. The transcontinental journey is certainly the most severe test to which a motor car can be put. Now that this trip has been made in the short time of fifteen days, we see no reason why it should not be used by other manufacturers as a demonstration test of their cars. It is doubtful whether any but a powerful lightweight machine could equal the record which has just been made.

MESSRS. WHITMAN AND CARRIS ON THEIR 30-HORSE-POWER, 6-CYLINDER FRANKLIN, FULLY EQUIPPED FOR ITS TRANSCONTINENTAL DASH.

Note the extension at the forward end of the bonnet for the purpose of increasing the draft of air to the motor cylinders.



EXHAUST SIDE OF THE 4 x 4, 6-CYLINDER, AIR-COOLED MOTOR OF THE FRANKLIN TRANSCONTINENTAL RECORD-BREAKING CAR.

Besides the fan at the front the flywheel has fan-blade spokes, which help to increase the draft. The auxiliary exhaust valves at the base of the cylinders also aid greatly in the cooling. The motor is completely incased, a steel pan being provided below, as shown.

NEW EXPERIMENTS ON FORMATION OF DIAMOND IN ELECTRIC FURNACE.

By Prof. HENRI MOISSAN.

UPON repeating the experiments which were described in a preceding memoir* we obtained the same results, namely, the formation of crystals having a composite structure or of drop-like appearance, and others such as octahedra with curved surfaces. These crystals are perfectly transparent and have a high refractive power, with a density near 3.5, seeing that they fall to the bottom in iodide of methylene, whose density is 3.4. They scratch the ruby and burn in oxygen without leaving any ash, giving carbonic acid. Some of them split up shortly after their formation, as sometimes happens to certain of the Cape diamonds when they have been separated from the blue earth, after coming from the deep mines of Transvaal. These experiments were since repeated in the same way by Sir William Crookes, who also obtained black and transparent diamonds. Sig. Majorana used a high pressure applied to the exterior of fused iron containing carbon in saturation and also prepared microscopic diamonds. The observations which we recently carried out upon a 400-pound block of meteoric iron from Diablo Cañon showed us that the diamonds were met with in the fissures of the meteorite in the center of the metal. Besides, these fissures were in relation by narrow cracks with the nuclei of iron sulphide or troilite which we previously examined together with M. Osmond. It seemed therefore logical to admit that the sulphur could have aided in separating the carbon from the iron. We found that the meteorite not only contained troilite, but also silicon in the form of silicide of carbon, and it was also known a long time since that it contained phosphorus. These different metalloids might have intervened in the separation and the crystallization of the carbon.

Accordingly we resumed the study of this question and operated in the following manner. We melted 150 grammes of Swedish iron cut in fragments of several cubic centimeters, each, in the electric furnace in the presence of sugar carbon. The saturation of the iron by the carbon at the temperature of the electric furnace is finished in two or three minutes with a current of 400 amperes and 120 volts. The crucible containing the fused metal is removed from the furnace and we add a solid piece of monosulphide of iron (about 5 grammes) which melts at once and mixes with the mass. The metal swells up and abundant gases are given off. After cooling, the metallic

* Article on Moissan Diamond Furnace and Experiments last year.

mass is treated by acids. The graphite is transformed into graphitic oxide, then into pyrographitic oxide, and the latter is destroyed by a mixture of boiling sulphuric acid into which are thrown about 50 grammes of nitrate of potash in small portions. After several alternate treatments of this residue by fluorhydric and sulphuric acids, then by fusion with fluorhydrate of potassium, it is washed, dried, and placed in iodide of methylene having a density of 3.4. The part which falls to the bottom is collected. By the above process no diamonds were obtained, but the result is quite different if the crucible containing the liquid iron with the added sulphide of iron is cooled suddenly in a mass of cold water. After the first phenomena of calefaction, the porous graphite crucible is rapidly penetrated by the water. The metallic mass is cooled on the exterior and a solid crust is formed. As we showed before, an internal pressure is thus formed and the carbon which deposits in the inner liquid part takes the form of the diamond.

The appearance of the metallic masses to which sulphur has been added is sometimes different from ordinary cast iron cooled in water. An external resistant portion is still formed, but the surface of the metal, in the case of sudden cooling, is covered with a black, spongy, and solid layer, which comes from the rapid solidification of the metal while in an emulsion form, the latter being due to the sudden disengagement of gas. If the gases have had the time to come out before the immersion in water, the metal has the ordinary appearance.

The diamonds which are obtained by this addition of iron sulphide have the same form as those which we prepared before. They appear in the form of drops, sometimes having octahedral points, or in superposed layers having octahedral characteristics. We obtained several of these octahedra and fixed them between two microscope glasses with Canada balsam. Some of these crystals break up several weeks after their preparation, while others contain black specks, and a great number present square markings and the parallel striæ which are often seen on natural diamonds. They all have an oily luster and a high index of refraction. We heated some of them in oxygen in a platinum trough as in the former experiments, and they burn

SPLASHING THROUGH MUD NEAR THE PLATTE RIVER, NEB.

without leaving any ash. The only difference which is found by adding the iron sulphide is that the yield of diamonds, although still small, is better than we have obtained up to the present. In a single mass we sometimes find eight or ten small diamonds, and half or two-thirds of them can be taken out by the naked eye with a fine steel point.

We carried out several series of experiments by adding silicide of iron or melted silicon to the iron saturated with carbon in the electric furnace, before cooling the mass suddenly in water. In this case we still obtained diamonds, and sometimes the yield was greater than that which the first experiments gave. But the great quantity of silicide of carbon which is produced, especially when melted silicon is used, makes it difficult to separate the diamonds in the iodide of methylene. It must not be forgotten that the carbon silicide prepared in the iron is always blue or green, as we showed in 1893, so that by using the microscope we cannot confound the silicide with the fragments of black or transparent diamond. Besides, as its density is only 3.12, it floats on the surface of the iodide of methylene.

The diamonds which are formed with silicon have more irregular forms than the preceding. There are many black and spotted diamonds. In these new conditions we obtained diamonds which have a great number of square markings. The ends of some fragments are terminated by piles of minute cubes. A few of the specimens broke up a few weeks or a few months after their formation, and showed surfaces also covered by very small cubes. In these preparations the drops were rarer and we found no octahedra. The yield was also somewhat greater than our experiments of 1893. Several times ten or fifteen small microscopic diamonds were separated from a single mass of iron. The largest of these specimens measures 0.75 millimeter (0.03 inch). An octahedra measures 0.2 millimeter (0.008 inch); several drops reach 0.4 and 0.1 millimeter (0.16 and 0.004 inch). These specimens are of the same order of magnitude as those which we took from the 400-pound Diablo Cañon meteorite, and some are even larger.

As to the optical properties of the specimens, they have an oily and characteristic aspect and a high refractive index. This latter property often enables us, with a little practice, to distinguish them when they are still mixed with other substances. We observed the action of the diamonds upon parallel and convergent polarized light. Their bi-refracting power is small and variable, without depending on the exterior form. In general, the optical characteristics of the specimens in polarized light are variable. To make a comparison with a well-known crystal which is found under the same conditions, the silicide of carbon, we may remark that there is no resemblance between the two kinds of crystals. The latter show a normal

RUSHING THE BIG MUDDY RIVER IN WYOMING.

bi-refraction which is much higher. Besides, the carbon silicide prepared in the iron is always strongly colored. The carbon silicide of the Diablo Cañon meteorite is green. Besides, this action of crystallized carbon upon polarized light has been long known. Although it belongs to the cubical system, the diamond presents well-marked phenomena of bi-refraction which were first studied by Brewster in 1815 and have been frequently observed by Jannetaz (1879), Hirchswald (1877), Mallard (1882), and others. This phenomenon is of a general order, and it is known at present that most of the cubical crystals show analogous effects of bi-refraction, such as alum, nitrate of lead, garnets, etc.

After these different experiments we did not judge it necessary to repeat the combustion by weight in oxygen, seeing that the three analyses published in 1894 are no doubt sufficient to solve the question. We may say that in the first case, 6 milligrammes of black diamonds gave 23 milligrammes of carbonic acid gas and that the ash left after the combustion was too small to be weighed. In the second case, 15 milligrammes of transparent fragments were burned and left a residue of 2.5 milligrammes of round and bright grains which did not burn in oxygen at 1,000 deg. C. These grains were not diamond ash, but were formed of a transparent matter rich in silicon which disappeared by an attack of fluorhydrate of potassium in fusion. The weight of 13 milligrammes of transparent diamonds burned in this analysis gave us 49.6 milligrammes of carbonic anhydride. Last, a third combustion of 5.7 milligrammes of transparent diamonds, this time treated beforehand by fluorhydrate of potassium, gave 20.5 milligrammes of carbonic acid gas, with no appreciable ash. These three figures are sufficient to establish the fact that the microscopic fragments obtained in our researches are formed of pure carbon.

The new experiments which we now publish, following our observations of the Diablo Cañon meteorite, thus corroborate our preceding researches. We may continue to regard the diamond as a variety of carbon which has been liquefied under a high pressure, while we demonstrated long ago that at the ordinary pressure all the specimens of carbon submitted to the

THE FRANKLIN ROUNDING A KNOLL NEAR THE SUMMIT OF THE ROCKY MOUNTAINS IN WYOMING.

action of a very high temperature become vaporized without passing through the liquid state, and they all furnish the same variety of carbon, namely, graphite.

To Perforate Thin Glass.—When particularly thin plates of glass are to be perforated, special precautions must be taken to avoid breaking them; for this purpose a ring of moist clay may be applied to the surface of the glass, leaving in the center a cavity of the exact diameter of the hole to be made. Pour melted lead into this space. A fracture of the glass will be produced according to the size of the circle, and the lead will fall through.—La Nature.

SOME FACTS ABOUT HOUSE FLIES.

THERE are several species of flies which are commonly found in houses, although but one of these should be called the house fly proper. This is the *Musca domestica* L. a medium-sized, grayish fly, with its mouth parts spread out at the tip for sucking up liquid substances. It breeds in manure and dooryard filth and is found in nearly all parts of the world. On account of the conformation of its mouth parts, the house fly cannot bite, yet no impression is stronger in the minds of most people than that this insect does occasionally bite. This impression is due to the frequent occurrence in houses of another fly (*Stomoxys calcitrans* L.), which is called the stable fly, and which, while closely resembling the house fly (so closely, in fact, as to deceive anyone but an entomologist), differs from it in the important particular that its mouth parts are formed for piercing the skin. It is perhaps second in point of abundance to the house fly in most portions of the Northeastern States.

A third species, commonly called the cluster fly (*Pollenia rudis* Fab.), is a very frequent visitant of houses, particularly in the spring and fall. This fly is somewhat larger than the house fly, with a dark-colored, smooth abdomen and a sprinkling of yellowish hairs. It is not so active as the house fly and, particularly in the fall, is very sluggish. At such times it may be picked up readily and is very subject to the attacks of a fungous disease which causes it to die upon window panes, surrounded by a whitish efflorescence. Occasionally this fly occurs in houses in such numbers as to cause great annoyance, but such occurrences are comparatively rare.

A fourth species is another stable fly, known as *Muscina stabulans* Fall., a form which almost exactly resembles the house fly in general appearance, and which does not bite as does the biting stable fly. It

ANOTHER SAMPLE OF NEBRASKA MUD, WHICH LASTED FOR 100 MILES.

breeds in decaying vegetable matter and in excrement.

Several species of metallic greenish or bluish flies are also occasionally found in houses, the most abundant of which is the so-called bluebottle fly (*Calliphora erythrocephala* Meig.). This insect is also called the blow-fly or meat-fly and breeds in decaying animal material. A smaller species, which may be called the small blue-bottle fly, is *Phormia terræ-novæ* Desv.; and a third, which is green in color and about the size of the large blue-bottle, is *Lucilia cæsar* L.

There is still another species, smaller than any of those so far mentioned, which is known to entomologists as *Homalomyia canicularis* L., sometimes called the small house fly. A related species is *H. brevis* Rond. *H. canicularis* is distinguished from the ordinary house fly by its paler and more pointed body and conical shape. The male, which is much commoner than the female, has large pale patches at the base of the abdomen, which are translucent when the fly is seen on a window pane. It is this species that is largely responsible for the prevalent idea that flies grow after gaining wings. Most people think that these little Homalomyias are the young of the larger flies, which, of course, is distinctly not the case.

Still another fly, and this one is still smaller, is a jet-black species known as the window fly (*Scenopinus fenestralis* L.), which in fact has become more abundant of later years. It breeds in the dust under carpets, and its larva is a white, very slender, almost thread-like creature.

In the autumn, when fruit appears on the sideboard, many specimens of a small fruit-fly (*Drosophila ampelophila* Loew) make their appearance, attracted by the odor of overripe fruit.

A small, slender fly is not infrequently seen in houses, especially upon window panes. This is *Sepsis violacea* Meig.

All of these species, however, are greatly dwarfed in numbers by the common house fly. In 1900 L. O. Howard, of the U. S. Department of Agriculture, made collections of the flies in dining rooms in different parts of the country, and out of a total of 23,087 flies 22,808 were *Musca domestica*, that is, 98.8 per cent of the whole number captured. The remainder, consisting of 1.2 per cent of the whole, comprised various species, including those mentioned above.

Musca domestica commonly lays its eggs upon horse

manure. This substance seems to be its favorite larval food.

At Salem, Mass., Packard states that he bred a generation in fourteen days in horse manure. The duration of the egg was twenty-four hours, the larval state from five to seven days, and the pupal state from five to seven days. At Washington Mr. Howard found in midsummer that each female lays about 120 eggs, which hatch in eight hours, the larva period lasting five days and the pupa five days, making the total time for the development of the generation ten days. This was at the end of June. The periods of development vary with the climate and with the season, and the insect hibernates in the puparium condition in manure or at the surface of the ground under a manure heap. It also hibernates in houses as adult, hiding in crevices.

The Washington observations indicate that the larvæ molt twice, and that there are thus three distinct larval stages.

The periods of development were found to be about as follows: Egg from deposition to hatching, one-third of a day; hatching of larva to first molt, one day; first to second molt, one day; second molt to pupation, three days; pupation to issuing of the adult, five days; total life round, approximately ten days. There is thus abundance of time for the development of twelve or thirteen generations in the climate of Washington every summer.

The number of eggs laid by an individual fly is undoubtedly large, averaging about 120, and the enormous numbers in which the insects occur is thus plainly accounted for, especially when we consider the abundance and universal occurrence of appropriate larval food. In order to ascertain the numbers in which house-fly larvæ occur in horse-manure piles, a quarter of a pound of rather well-infested horse manure was taken on August 9, and in it were counted 160 larvæ and 146 puparia. This would make about 1,200 house flies to the pound of manure. This, however, cannot be taken as an average, since no larvæ are found in perhaps the greater part of ordinary horse-manure piles. Neither, however, does it show the limit of what can be found, since about 200 puparia were found in less than 1 cubic inch of manure taken from a spot 2 inches below the surface of the pile where the larvæ had congregated in immense numbers. —Abstracted from a Bulletin issued by the Dept. of Agriculture.

SOME RUDIMENTARY STRUCTURES.*

By R. LYDEKKER.

ON a first visit to an English assize court, the stranger, if he occupy a sufficiently elevated position, will scarcely fail to notice the presence of a small black patch on the top of the full-bottomed wig of the presiding judge, and, if he be of an inquiring disposition, he will want to know the reason for this apparently useless feature. Reference to any treatise on the history of costume will inform him that this apparently unmeaning patch is the last remnant or survival of the coif, or black cap, with pendent lappets, originally worn by the "sergeants learned in the law," from among which body the judges were formerly selected. The patch affords therefore an excellent example of a structure which, although now perfectly useless, once had a definite and more or less important function. In other words, it exactly corresponds to what are commonly called rudimentary structures in the animal kingdom. I say commonly called rudimentary structures, purposely, because in scientific circles they are now more generally designated vestigiary structures; and, strictly speaking, quite rightly so, for a rudiment properly means the commencement of anything, whereas these are the last vestiges of the structures they represent. They are decadent, and not in-

FIG. 1.—THE LEFT FORE AND HIND LIMBS OF A HORSE, TO SHOW THE CALLOSITIES, OR "CHESTNUTS."

cipient. Nevertheless, since the term vestigiary is somewhat cumbrous, and by no means so well known as rudimentary, I shall take leave to use the latter, especially as it is employed by Darwin, in this sense, in the "Origin of Species."

Rudimentary, or more or less completely functionless organs are extremely common in both the animal and the vegetable kingdoms; and they can have but one meaning. That is to say, they afford practically decisive and irrefutable evidence in the minds of all unprejudiced persons of the truth of the doctrine of evolution. For it is absolutely inconceivable that such useless structures, which in many instances can be traced by regular gradations into those which were evidently functional, could have been created in their present condition. Indeed, if we had no other evidence in favor of the evolution of animal forms from pre-existing types, it is perhaps not too much to say that the evidence of these rudimentary structures

FIG. 2.—PART OF THE SKIN OF THE TAIL OF A PYTHON, SHOWING THE HORNY SPURS REPRESENTING THE HIND LIMBS.

would alone be sufficient to prove the truth of that great doctrine.

Since rudimentary structures are so common in nature we suffer from an *embarras de richesses* in attempting to select instances to form the subject of a short article; and the reader must consequently be not surprised if he finds no mention of many cases of this kind with which he may be more or less familiar. As a matter of fact, cases of this nature to which the present writer has had occasion to devote special attention form the chief of those noticed in this article.

Among the larger animals of the present day, no species is more highly specialized than the horse (and its immediate relatives), and it would consequently be only reasonable to expect that in the course of its evolutionary progress this creature should have found certain elements in its organization superfluous, and

FIG. 3.—THE VERMIFORM APPENDIX, AND THE ADJACENT PARTS OF THE HUMAN ALIMENTARY CANAL.

should therefore have done its best to discard them. This expectation is fully realized by the actual state of the case; and it may be regarded as a fortunate circumstance that the total elimination of such superfluous structures appears to be an exceedingly difficult process, so that their rudiments, or vestiges, are frequently left to tell the tale of their gradual degeneration.

As regards some of the rudimentary organs occurring in the horse, one of the most interesting is the remnant in the skull of the eastern breeds, of the cavity in front of the eye, which in the extinct three-toed hipparions probably contained a gland similar to the larmier, or face-gland, of deer and many antelopes.

At first sight there may seem to be little, if any, connection between this last vestige of the hipparion's face-gland, and those curious warty structures on the inner side of the limbs of the horse, which are commonly known as callosities, or chestnuts (Fig. 1). It appears to be a very general belief that these structures are for the purpose of serving as cushions, or pads, to ease the pressure on the limbs when the animal is lying down. This, however, is obviously out of the question; and it is quite certain that the callosities are now useless remnants of structures that were once functional. The question is what those structures were. One theory is that they were foot-pads, or cushions, comparable to those on the foot of a dog or a cat; and in order to support this hypothesis, it has been stated that they are situated much lower down on the fœtus than in the adult, so as to be situated on what corresponds to the foot of other mammals. This, however, is not the case.

A much more probable theory is that these callosities represent scent-glands, comparable to those on the limbs of deer. Strong support to this is afforded by the fact (as I am informed) that the secretion which exudes from these callosities when cut will cause a horse to follow any substance anointed therewith; and also by the poacher's practice of carrying a fragment of one of them to keep his dog quiet. That a rudimentary foot-pad would have any effect of this kind is, of course, quite out of the question, although nothing is more likely than that such emanations should proceed from a decadent foot-gland.

In regard to the connection between the rudimentary face-gland of certain horses, and the callosities, it may be noted that both face-glands and foot-glands appear to be for the purpose of aiding animals in finding the whereabouts of their fellows; the leg or foot glands leaving a scent on the grass or jungle through which they pass. If, however, animals live on open plains, as is the case with horses and zebras, where they can see one another at long distances, such aids may be quite unnecessary. We know that the horse and its kindred have lost the facial scent-glands of their ancestors, and what is more likely than that they should at the same time have discarded their leg-glands, of which the callosities are the last remnants?

That the horse does retain vestiges of the foot-pads of its ancestors, who applied a portion of the sole of their foot, instead of only the nail (hoof) of the middle toe, to the ground, appears, however, to be undoubted. At the hinder basal extremity of the second joint of the pastern is a curious little horny spur (very conspicuous in the fœtus), known to veterinarians as the ergot; and this ergot seems to represent the central pad of the foot of the tapir. As this part of the foot of the horse does not touch the ground, the pad is of no functional importance, and has consequently degenerated to this curious little horny spur.

Other rudimentary organs in the horse are the splint-bones lying on either side of the upper end of the fore and hind canon-bones, and representing the functional metacarpal and metatarsal bones, and sometimes even the lateral toes of the hipparion. In domesticated horses not only are these bones useless, but they are actually harmful, producing the disease called splint. Even this does not exhaust the list of rudimentary structures in the horse. In the "knee," or carpus, of the hipparion exists a bone known as the trapezium, which supports one of the aforesaid metacarpal bones of the lateral toes. In the horse this bone is functionless and very minute, and is present only in about fifty out of every hundred individuals; so that it is evidently about to follow in the wake of the lost lateral toes.

In the horse only certain elements of the limbs have become rudimentary, in order to permit the greater development of other elements of this part of the skeleton. In some groups of animals, on the other hand, one or both pairs of limbs are, in many instances at any rate, completely wanting; and had it not been that they are occasionally represented by minute vestiges, we should have had no direct evidence that they ever existed in the group. As it is, we are absolutely certain (if evolution be the true explanation of the resemblance of animals to one another) that snakes and whales are descended from creatures with four limbs.

In regard to snakes, most members of the group show no traces of limbs, either externally or internally; but in the family groups which include the boa-constrictors and pythons (the *Boidæ* of naturalists) it fortunately happens that in many species, at any rate, minute vestiges of the hind-limbs are retained, as if for the very purpose of telling us the story of their ancestry, for it is quite certain that in most instances, at all events, these rudiments are absolutely useless. The second illustration to this article shows the external vestiges of the hind-limbs in an African python (*Python sebæ*) over twenty feet in length. These vestiges take the form of a pair of horny spurs, or claws, about three-quarters of an inch in length, and situated on the under surface of the body at the commencement of the tail. In the specimen figured, the skin has been slit along the middle line of the belly, so that the two claws are separated from one another by the width of the skin of the back and flanks, whereas in nature they would be comparatively close together. Each claw in this specimen was supported on a bony core, corresponding to the terminal bone of one of the toes of a lizard's foot, while embedded in the flesh beneath was a much stouter bone, probably representing the femur, or thigh-bone, and also a mi-

FIG. 4.—TIP OF TAIL OF LION (ON THE LEFT), AND OF NAIL-TAILED WALLABY (ON THE RIGHT), SHOWING HORNY SPUR AND NAIL.

nute nodule, which may be the last remnant of the pelvis. It must not, however, be supposed that all pythons exhibit these vestiges as distinctly as in this specimen. On the contrary, in the skin of a Malay python (*P. molurus*) of five-and-twenty feet in length, which I recently examined, the external rudiments of the limbs were minute lobes, scarcely larger than the head of a big pin. Somewhat similar vestiges of the hind-limbs are retained in the small burrowing tropical snakes of the family *Typhlopidæ*, as well as in the members of a nearly allied group; but in no snakes have any traces of the front-limbs been detected.

* Knowledge and Scientific News.

These vestiges, then, afford decisive evidence that snakes are descended from reptiles with functional hind-limbs, from which it may also be inferred that their early ancestors were four-limbed; the front limbs, as in the case of certain snake-like lizards, being the first to disappear. The further inference that those snakes which retain rudimentary hind-limbs are the most archaic members of their kind, has been recently confirmed by the discovery that pythons and boa-constrictors display certain primitive features in other parts of their anatomy.

Space admits of but very brief allusion to the case of whales. As everyone knows, all the members of the order Cetacea, inclusive of whales, dolphins, porpoises, etc., have but a single pair of limbs, the front ones, which are modified into paddles for swimming. It is, however, far less well known that deep down among the muscles of the body of the Greenland right-whale and its immediate relatives are imbedded certain small and useless bones which represent those of the pelvis, and part of the hind-limbs of less specialized mammals. These rudimentary bones are alone sufficient to demonstrate the descent of whales and dolphins from four-limbed ancestors; and when taken in connection with the fact that cetaceans are air-breathing (as opposed to gill-breathing) creatures, they lead to the conclusion that their ultimate ancestors were terrestrial. Curiously enough, it is the most specialized whales (that is to say, the true, or whalebone whales) that alone retain rudiments of the hind-limb itself; these vestiges in the toothed whales, such as the sperm-whale and dolphins, being restricted to the bones of the pelvis. In this respect, then, cetaceans are unlike snakes, in which, as we have seen, it is the most primitive forms that alone retain vestiges of limbs.

Turning to the subject of the third illustration, we have an exceedingly interesting example of a more or less completely rudimentary structure, in the so-called worm-like appendage, or *appendix vermiformis*, of the human blind gut, or *cæcum*. In this connection it may be well to mention incidentally that the disease to which this organ is so frequently subject, derives its name of *appendicitis* from the organ itself, and its alternative title of *typhlitis*, from Greek τυφλός, blind, in reference to the blind gut of which the appendix forms the termination.

In a great number of mammals, both herbivorous and carnivorous, there exists at the angle formed by the junction of the small intestine or ileum with the large intestine or colon, a large blind pouch or diverticulum, which probably aids in the digestion of food by preventing its too rapid discharge. The cæcum, as it is called, is remarkably well developed in the horse and the dog, in the latter of which it is coiled in a spiral manner. In the human subject, on the other hand, the cæcum proper is very short, but is prolonged by the aforesaid vermiform appendage, which is usually from four to five inches in length, with a caliber of only about one-third of an inch. This appendage corresponds to the coiled cæcum of the dog, of which it is obviously an aborted rudiment. As many of us know by sad experience, it is only too likely to become choked by closely packed, partially digested, or undigested food; and the opinion has been very generally held that it is an altogether superfluous and useless organ whose complete elimination would be an unmixed advantage to the human race. For instance, on page 282 of "The Student's Darwin," by Dr. Aveling, we find the following statement in reference to the vermiform appendage:

"It is to man useless. Nay, it is worse than useless. It is at times a special death-dealer. Small, hard bodies, as the seeds of fruits, entering the appendix, cause inflammation and death. In the animals lower than man, this organ is of great size and functional importance. That of the orang-utan is long and convoluted."

On the other hand, an eminent surgeon has recently expressed the opinion that the appendix may still have a certain amount of digestive function. To controvert such an opinion would obviously be presumption on my part; but whether or no it still retains any active function, the structure in question is evidently a pronounced example of a rudimentary organ, and one which, by the way, leads to the conclusion that man is descended from an animal furnished with a long and complex cæcum. Incidentally, it may be mentioned that, in addition to man, the only animal possessing a vermiform appendix is the Australian wombat, a member of the marsupial order. Truly a remarkable instance of parallelism in retrograde development!

With Fig. 4, I come to the last section of my subject, and I must confess that I am by no means certain that it properly belongs to my subject at all. The object represented on the left side of the photograph in question is the tip of the tail of a lion, showing the presence of a small horny prickle or spur (*s*) buried among the terminal tuft of hair. In the natural condition, it should be mentioned, the spur was completely concealed by the long hair, and it was only by cutting away a portion of the latter that it was made visible. What may be the history or use (if it has a use) of this spur, no one seems to know, and I have no intention of hazarding a guess. The old story, that it was for the purpose of enabling the lion to goad itself into a fury when about to attack, is obviously an absurdity, more especially as it seems that the spur is developed in only a comparatively small percentage of lions. If any of my readers can solve this problem, they will be the means of removing one blank from future zoological text-books. I fear it will not help them much to learn that one species of kangaroo, or rather wallaby, possesses a very similar caudal appendage, which is, however, of a somewhat more nail-like form, as shown at *N*, on the right side of Fig. 4.

THE COLORS OF THE SKY AND THE SOLAR DISK.

By PROF. G. SAGNAC.

1. THE Modern Theory of the Blue Color of the Sky.—Science, after many wanderings, has returned to the explanation which Leonardo da Vinci suggested when he compared the color of a cloudless sky to that of smoke seen against a dark background.

The atmosphere, which, according to Arrhenius, extends to a height of 125 miles above the sea level,

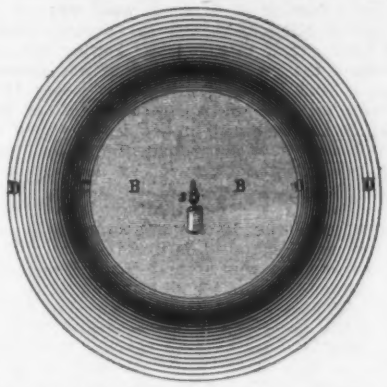


FIG. 1.—SOURCE OF LIGHT VIEWED THROUGH A MIST.

C D, colored rings. B B, central blue field.

breaks up the rays of the sun, scatters them in all directions, and thus becomes luminous and visible. Its color is the result of selective diffusion. In other words, the atmosphere diffuses most powerfully the rays of shortest wave length, diffusing blue more strongly than green, and violet more strongly than blue. The wave lengths whose absence from sunlight produces the dark Fraunhofer lines of the solar spectrum are also absent from the light diffused by the sky, the spectrum of which shows the Fraunhofer lines unchanged in position.

2. Artificial Production of the Blue Color of the Sky. The Blue Center of Diffraction Rings.—When a pane of glass is breathed on the moisture of the breath condenses on the glass in the form of fine dew. A source of light seen through the glass thus coated appears surrounded by colored rings (Fig. 1). If the drops of water which compose the coating are fine enough and the source of light is sufficiently small or distant, the area within the innermost ring has a uniform blue tint resembling the color of a cloudless sky.

These effects are due to a diffusion or diffraction of the incident light by the drops of water. Similar effects are produced by fine powders like lycopodium. The phenomena are not affected by the physical state of the diffracting particles, but only by their size. The smaller they are, the larger the colored rings become, until, when the diameter of the particles is reduced to less than a micron (1/1000 millimeter, or 1/25000 inch) the rings disappear by expansion and the central blue fills the whole field of vision. In other words, every illuminated collection of particles less than 1/25000 of an inch in diameter radiates blue light, like that of the sky, in all directions.

3. Blue Clouds Produced by Precipitation.—These particles, instead of being spread over a pane of glass, may be distributed throughout a volume. In this case we have a blue diffusion cloud—that is, a cloud which appears sky-blue when it is illuminated by white light and seen against a dark background. Such a cloud produces the faint opalescence which precedes the precipitation of solid particles from a liquid or a gas. Tyndall* made some very beautiful experiments on the formation of such blue clouds in air, but similar effects are more easily obtained with liquids. If one part by weight of gum mastic is dissolved in ten parts of strong alcohol and the solution is added, drop by drop and with constant stirring, to a glass of distilled water, the mastic is separated, but remains in suspension, in particles so fine that the water appears blue when seen by daylight against a dark background. If the glass vessel is rectangular and is placed in the path of a sunbeam or a beam projected by an electric lantern (Fig. 2), the beam appears in the liquid as a blue cylinder or cone, *A*, *B*, *C*, *D*. As the mastic settles very slowly the phenomenon can be observed at leisure.

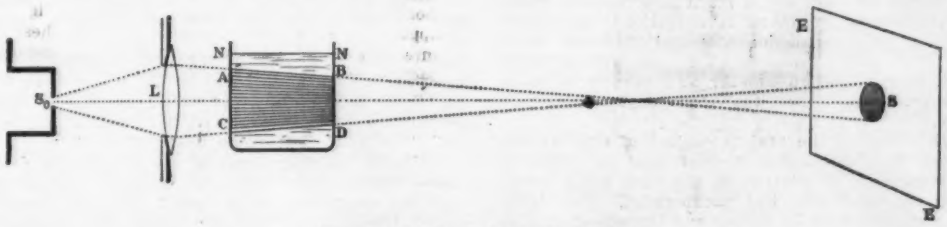


FIG. 2.—ARTIFICIAL SUNSET.

S_0, circular aperture before lantern. S, its image projected by the lens L. N, glass vessel containing diffusing liquid. A B C D, blue trace of beam of light in the liquid

* "Heat as a Mode of Motion," also Proc. R. S, 1868.

Lippmann has obtained a very intense and permanent blue with silver bromide suspended in solidified gelatine, albumen, or collodion. For example, gelatine is dissolved in hot water and a little albumen is added to precipitate impurities. Then a solution of potassium bromide is added and the mixture is allowed to cool. A concentrated solution of silver nitrate is poured on the solidified gelatine, into which it penetrates to the depth of a millimeter (1-25 inch) in a few minutes, forming in the potassium bromide fine particles of silver bromide which produce a blue coloration on a dark background. The gelatine greatly retards the agglomeration of the particles which long remain of "Tyndallian" fineness.

Plates prepared by a similar process for photographing in colors by Lippmann's interferential method also contain particles of gelatino-bromide of silver of extreme fineness,

4. Artificial Sunset.—If, in the experiment illustrated by Fig. 2, the image of a circular aperture placed before the lantern is projected on a white screen by means of the beam which traverses the liquid, this image will appear yellow or orange, the depth of its tint varying with the thickness of the vessel of liquid and the quantity of mastic in suspension. Similarly, a disk of white paper appears yellow or orange when it is viewed through the liquid.

The earth's atmosphere produces an effect of the same character upon the disk of the sun, to which it gives a yellow tinge by subtracting the rays of short wave length from its beams and diffusing them in all directions to produce, as we have seen, the blue color of the sky. As the observer rises through the atmosphere this effect diminishes and the sun's beams become richer in blue, violet, and especially ultra-violet radiations. Conversely, as the sun approaches the horizon its beams traverse a layer of atmosphere of steadily increasing thickness and its disk passes from pale yellow to deep yellow, orange, and finally red. A succession of tints similar to those of the setting sun is easily obtained by replacing the mastic emulsion of the above experiment with a solution of 1 part by weight of sodium hyposulphite in 100 parts of distilled water and adding a few drops of dilute sulphuric or hydrochloric acid. In a few minutes an opalescent blue precipitate of sulphur begins to form, the color of which gradually increases in intensity at first, but finally turns to white in consequence of the increase and coalescence of the particles of sulphur. If these changes occur too rapidly they may be retarded by the prompt addition of a drop or two of ammonia.

While these changes are occurring the light transmitted by the liquid passes from white to yellow, orange, and red, and the image on the screen assumes successively the various complex tints of the setting sun. (A disk of white paper, viewed through the liquid, undergoes similar changes in color.)

If the vessel is not disturbed the sulphur accumulates, especially near the bottom, where it plays the part of the fog-laden lower strata of the atmosphere. The image on the screen (or white disk seen through the liquid) then appears like the solar disk slowly sinking into the mists of the horizon and showing at once every tint from yellow to dark red.

5. Nature of the Particles that Give Rise to the Blue Color of the Sky.—The finely divided matter which disturbs the optical homogeneity of the atmosphere may consist, in part, of solid dust.* The eruption of Krakatoa, in 1883, projected large quantities of ashes to a great height above the earth. The finest particles evidently remained suspended for years at a height exceeding a mile, for even from elevated viewpoints the sun appeared, for several years after the eruption, surrounded by colored rings, which inclosed a central field of an intense blue color. Similar phenomena followed the eruptions of Mt. Pelée in 1902 and 1903. But all such dust falls in time and volcanic ashes, ice crystals, and other foreign matter can hardly be the principal cause of the blue color of the sky. We are led, therefore, to consider the diffusive action of the molecules of the air itself. According to the writer's personal view, the diffusive effect of a given mass of finely divided matter should be proportional to the mean distance between its particles, divided by the wave length of the light diffused. Every substance, even the purest and most homogeneous, must diffuse light in virtue of its molecular discontinuity. In gases at atmospheric pressure the mean distance between molecules is about ten times as great as it is in solids and liquids and the optical diffusion must be correspondingly increased. At the sea level the mean distance between the molecules of the atmosphere is about 0.01 of the wave length of green light. As the wave length diminishes, the diffusion must increase from the red to the violet end of

* See "Les Métaux dans l'Atmosphere," by A. Ditte, Revue Scientifique, Dec. 3, 1904.

the spectrum, thus favoring the production of blue and violet tints. Also, as the pressure decreases and the mean distance between molecules increases as we ascend from the sea level, the diffusion must increase. It follows that a given mass of air at a great altitude has a greater effect in producing the blue color of the sky than an equal mass of air has at the sea level. Calculation shows that the blue color of the sky, assuming it to be caused by diffusion by air molecules, is due chiefly to the atmospheric strata which lie above the tops of the highest mountains. This result is confirmed by my observations in the Alps.*—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Science au XXme Siècle.

THE INTERNAL HEAT OF THE EARTH AND THE THICKNESS OF THE EARTH'S CRUST.

IN pursuance of the calculations advanced by Prof. Rutherford, that there may be enough radium in the earth to account for the temperature gradient observed near the surface, and that possibly the earth's internal heat is due to radio-activity, the Hon. R. J. Strutt, F.R.S., who has already made many important contributions to our literature upon radium and its radio-active phenomena, has been following up Prof. Rutherford's theses for some time past, and recently communicated to the British Royal Society the results of his investigations "On the Distribution of Radium in the Earth's Crust, and on the Earth's Internal Heat." For the purposes of these researches Mr. Strutt gathered together from all parts of the world various representative rocks of which the earth's crust is composed, and ascertained the quantity of their radium contents, and from the results therewith obtained has prepared an interesting computation concerning the depth of the earth's crust. Owing to the extent of these investigations and the care with which they have been carried out, the results obtained are very surprising in their character.

As is well known, the crust of the earth which is accessible is composed of igneous rocks and of sedimentary material, which is the result of action arising from geological changes upon these rocks. In order to obtain conclusive data concerning the radium content of the igneous rocks they were examined directly, since they afford more conclusive data concerning the average radium content of the earth's crust. Certain sedimentary rocks were examined, but Mr. Strutt does not attach much importance to them. In the course of these investigations, meteorites, owing to their possessing a special individual interest, were also examined. The rocks investigated were twenty-eight in number and were of a representative character, as the accompanying table will show.

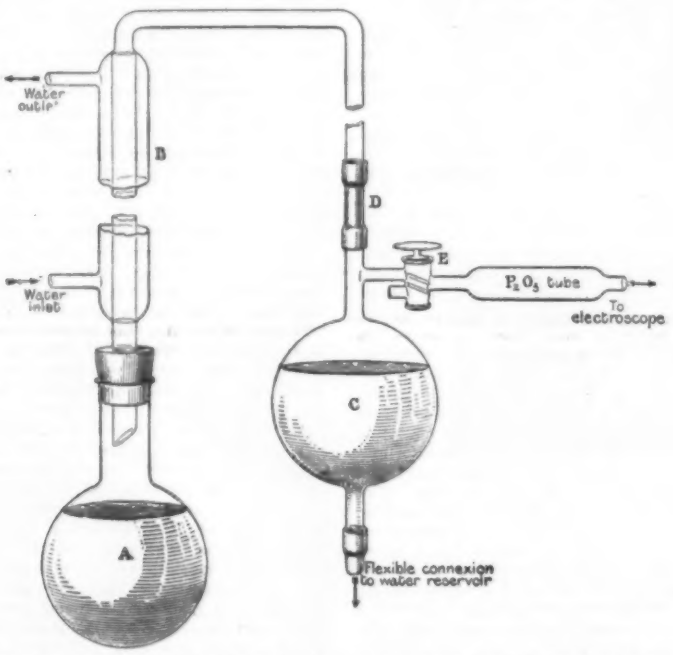
The extent of the radium content of each variety of rock was quantitatively determined by means of its emanation, a solution of the rock being stored until the emanation had accumulated. The latter was then extracted by boiling and introduced into an electroscope and the increased rate of leak produced was the measure of the amount of radium present. In order to render this measuring process absolute, the process was again repeated with a uranium mineral the radium content of which was known.

For the purpose of obtaining the emanation quantitatively, the various rocks were first dissolved by chemical means. With regard to limestones and metallic meteorites these were dissolved by solution of hydrochloric acid. For the dissolution of the siliceous rocks fusion with alkaline carbonate was necessary. Fifty grammes of the rock were pulverized until fine enough to pass through a sieve of ninety threads to the inch, such fineness being requisite to insure the rapid and easy decomposition of the rock.

* Annuaire du Club Alpine Français, 1902.

A mixture of 250 grammes of anhydrous sodium and potassium carbonates was then melted in a platinum basin by a gas blowpipe and directly the carbonate was melted the powdered rock was thrown onto its surface in small quantities at a time until the whole quantity had been so added, and the fusion was continued for about an hour after all effervescence was over. Hot water was added to the residue in order to dissolve out the alkaline silicates and carbonate, and the portion insoluble in water was dissolved in hydrochloric acid. Some silica always separated from the acid solution and was permitted to remain floated in it. The two solutions, aqueous and acid, were then set aside in separate flasks, and allowed to stand for a number of days. A week was the minimum period allowed, though the average time extended from two to three weeks. During this period any radium the rock might contain was generating emanation, and in practically three weeks the accumulation attained the maximum. The fraction of this maximum generated in any lesser period could be calculated from the equation for the rise of activity originally formulated by Rutherford and Soddy.

The apparatus for quantitatively extracting the emanation is shown in the accompanying diagram. The solution is contained in the flask, *A*. The accumulated emanation is at first partly dissolved and partly contained in the air which occupies the upper part of the flask. The latter is uncorked and connected to the lower end of the condenser, *B*, as rapidly as possible, so as to avoid any loss of emanation. A burner is then placed under the flask, *A*, the contents of which are boiled so as to expel the radium emanation. The steam generated rises into the condenser, *B*, and drops back, while the air charged with emanation passes out into the gas container, *C*, displacing the water which previously filled it. The



APPARATUS FOR DETERMINING THE EMANATION FROM ROCKS.

boiling operation is continued for about one hour and at the end of that period the cooling water is run off from the jacket of condenser, *B*. All air and emanation is scoured out from *A* and the connecting tubes into *C* by the passage of steam; the India-rubber connection at *D* is then nipped and the burner underneath *A* immediately withdrawn. All emanation is thus collected in the receptacle, *C*, and it has only to be transferred to the electroscope when cold. The latter was then exhausted and the emanation admitted through the stopcock, *E*, and a drying tube. Air was then admitted up to atmospheric pressure into the electroscope, and after standing three hours, during which period the active deposit formed, the rate of leak was read. During the progress of the investigation the normal leak of the electroscope was repeatedly determined. The values in scale divisions per hour were as follows: 24, 25.3, 24.1, 24, 23, 20.6, 21.7, 22.3, 22.5, 22.1; mean nearly 23.

Owing to the minuteness of the effect to be determined extreme care had to be exercised to ascertain that the emanation really issued from the material under investigation and not from any extraneous source, since in this way the investigator was deceived in concluding that mercury emitted emanation. The solutions of the reagents utilized were separately tested for emanation after they had been standing sealed for two weeks and the results were as follows:

	Rate of leak.
Sodium carbonate, 250 grammes.....	23.9
Potassium carbonate, 250 grammes.....	24.2
Hydrochloric acid, 500 c.c.....	24.0
Water (Cambridge supply) 2,000 c.c....	24.0

In none of these cases does the leak measurably exceed the normal to the electroscope, so that it may be concluded that the reagents employed to decompose the rocks are not responsible for the emanation obtained. Owing to the water used at Cambridge, where the investigations were carried out, having been found by Prof. J. J. Thomson to contain dissolved emanation, it was carefully boiled for the purpose of expelling this before use and the water in the gas holder was changed after each experiment.

For the purposes of absolute measurement a uranium mineral of known radium content was employed, since this has been determined in absolute measure by Rutherford and Boltwood. According to their researches the radium associated with one gramme of uranium is 7.4×10^{-7} gramme. This value was used by Mr. Strutt in preference to his own, since they had tested the heat production of their standard radium, while he had no test for the purity of his. The uranium minerals used for standardization were torbernite—copper-uranium phosphate—containing 60 per cent U_3O_8 (= 51 per cent uranium) and pitchblende containing 73.5 per cent U_3O_8 (= 62.4 per cent uranium). The rate of leak due to the emanation produced by a few milligrammes of each of these in one day was determined, and from this the quantity of radium was deduced which would in an *indefinite time* produce enough emanation to give a leak of one division per hour. This is the constant given in the last column of the following table:

STANDARDIZATION EXPERIMENTS.

Mineral.	Percentage of Uranium (metal).	Quantity in grammes.	*Rate of leak due to emanation accumulated in one day.	Constant deduced.
Torbernite	51.0	0.0076	214.0	2.8×10^{-12}
Torbernite, same sample	51.0	0.0076	209.0	$2.80 \times$ "
Torbernite	51.0	0.0048	116.5	$2.56 \times$ "
Torbernite, same sample	51.0	0.0046	113.0	$2.64 \times$ "
Pitchblende	62.4	0.0063	207.0	$2.41 \times$ "
Pitchblende, same sample	62.4	0.0063	202.0	$2.45 \times$ "

* Corrected for normal leak of electroscope.

It will be seen that the mean value for the constant is 2.45×10^{-12}; or a leak equal to one scale division per hour represents 2.45×10^{-12} gramme of radium if the sample examined has had time to produce its maximum amount of emanation.

The method of determining the radium content of a rock was as follows, the two rocks in question which were investigated being granite from the Cape of Good Hope and olivine rock from the Isle of Rum, respectively. These two rocks represent rocks of high and low radium content respectively.

The Cape granite was powdered and 50 grammes dissolved in the manner already described and the solutions were permitted to stand from March 21 to March 26, giving 60 per cent of the maximum amount of emanation.

	Scale divisions per hour.	Corrected.
Emanation from acid solution..	103	80.0
Emanation from alkaline solution	31	8.0
Total: 88.0 scale divisions per hour.		

Thus the equilibrium amount of emanation would give 146 scale divisions per hour, or per gramme of rock $\frac{146}{50} = 2.92$ scale divisions per hour. Thus, one gramme of rock contains $2.92 \times 2.45 \times 10^{-12}$ grammes, or 7.15×10^{-12} gramme radium.

With regard to the olivine rock, the same pulverizing process was carried out and the solution allowed to stand from January 31 to February 19, giving practically the equilibrium amount of emanation:

	Scale divisions per hour.	Corrected.
Emanation from acid solution.	34.0	11.0
Emanation from alkaline solution	25.8	2.8
Total: 13.8 scale divisions per hour.		

One gramme of rock would give 0.276 scale divisions per hour and contains $2.45 \times 0.276 \times 10^{-12} = 0.676 \times 10^{-12}$ gramme radium. In this example is represented nearly the lowest radium content encountered among igneous rocks. It will be observed that the leak produced by the emanation is even in this unfavorable instance about half that normal to the electroscope, and is therefore quite distinctly marked. Furthermore, it is noticeable that the alkaline solution contains only a small proportion of the total radium present in the original rock. In the following table are given the results attained with the various igneous rocks investigated and in order of radium content. (See next page.)

It is observable that, generally speaking, rocks like granite having a high percentage of silica are richer in radium than basic rocks, though the rule is by no means invariable.

Determinations have also been made on certain meteorites—one of a stony composition, three samples of meteoric iron, and one a sample of native iron from Disco Island, Greenland. The quantities available have varied and are shown in the accompanying table. Where the radium is entered as 0 it signifies that no leak could be obtained which could be clearly distinguished from that normal to the electroscope.

It is a noticeable point that the stony meteorite contains approximately as much radium as those basic rocks which it resembles in general composition. No evidence of the existence of radium was observed in the meteoric iron and only a small percentage in the Greenland native iron, due, Mr. Strutt opines, to the

No.	Name of Rock.	Locality.	Density.	Radium per gramme in grammes.	Radium per cubic centimeter in grammes.
1	Granite	Rhodesia	2.63	9.56 x 10^{-13}	25.2 x 10^{-13}
2	Granite	Lamorna Quarry, Cornwall	2.62	9.35 x "	24.5 x "
3	Orcon syenite	Brevig, Norway	2.74	9.30 x "	25.5 x "
4	Granite	Rosemorran	2.62	8.43 x "	22.1 x "
5	Granite	Cape of Good Hope	2.67	7.15 x "	19.1 x "
6	Granite	Near Carbis Bay, Cornwall	2.61	6.90 x "	18.0 x "
7	Granite	Shap Fell, Westmoreland	2.65	6.63 x "	17.6 x "
8	Elæolite syenite	Laurdal, Norway	2.70	4.88 x "	13.2 x "
9	Granite	Haytor, England	2.61	3.69 x "	9.64 x "
10	Blue Ground	Kimberley	3.06	3.37 x "	10.3 x "
11	Leucite sanidine	Mt. Somma, Vesuvius	2.72	3.33 x "	9.07 "
12	Hornblende granite	Assouan, Egypt	2.64	2.45 x "	6.47 x "
13	Pitchstone	Isle of Eisg	2.61	2.16 x "	4.97 x "
14	Hornblende diorite	Near Heidelberg	2.80	1.98 x "	5.73 x "
15	Augite syenite	Laurvig, Norway	2.73	1.96 x "	5.07 x "
16	Peridotite	Isle of Rum	3.15	1.37 x "	4.33 x "
17	Olivine basalt	Talisker Bay, Skye	2.89	1.33 x "	3.82 x "
18	Olivine eucherite	Isle of Rum	2.97	1.28 x "	3.80 x "
19	Basalt	Victoria Falls	2.75	1.26 x "	3.44 x "
20	Hornblende granite	Leicestershire	2.71	1.25 x "	3.38 x "
21	Dolerite	Isle of Canna	2.95	1.24 x "	3.65 x "
22	Greenstone	St. Ives, Cornwall	2.89	1.14 x "	3.41 x "
23	Basalt	Giant's Causeway	2.80	1.03 x "	2.89 x "
24	Serpentine	The Lizard, Cornwall	2.60	1.00 x "	2.60 x "
25	Granite	Isle of Rum	2.61	0.723 x "	1.89 x "
26	Olivine rock	Isle of Rum	3.23	0.676 x "	2.18 x "
27	Dunite	L. Scavig	3.34	0.664 x "	2.22 x "
28	Basalt	Disco Island, Greenland	3.01	0.613 x "	1.84 x "

siliceous material present in this iron which had been filtered off, decomposed by fusion, and added to the main solution.

With regard to the earth's internal heat, from the careful calculations made by Mr. Strutt, on the assumption that the earth is in thermal equilibrium, and that the whole of the internal heat is due to radium, the mean quantity per cubic centimeter is estimated to be not much in excess of 1.75×10^{-13} gramme per cubic centimeter, on the supposition that the heat production of radium is not materially diminished under the conditions prevailing inside the earth. The experiments carried out show that 5×10^{-12} gramme per cubic centimeter of radium is a representative value, and if anything is an under-estimation. Consequently, on this basis not more than about one-thirtieth of the earth's volume can consist of material similar to that encountered on the earth's surface, thereby giving a depth of about 45 miles for the rocky crust of the earth, assuming the total absence of radio-active material within. With regard to the temperature of the earth at that depth, this is estimated by Mr. Strutt to approximate 1,530 deg. C., a point considerably below the melting point of platinum. This result is based on the provisional assumption that the heat production of radium is practically the same throughout the earth's crust as under surface conditions, and this fact is justified by the results of

METEORITES.

Material.	Locality.	Quantity taken.	Radium per gramme
Stony meteorite	Charmsala	50 grammes	1.12 x 10^{-12}
Meteoric iron	Thunda	60 "	....
Meteoric iron	Augusta Co., Va., U. S. A.	32 "	....
Meteoric iron	Santa Catarina	40 "	....
Native iron	Greenland	300 "	0.424 x 10^{-12}

previous investigators, who ascertained that the activity of radium emanation and its products were substantially the same at temperatures of 1,200 deg. C. as at the ordinary temperature, though evidence was obtained of a slight change of activity in one of its products. There is thus no reason to believe that a notable change of activity sets in before 1,500 deg. C. is reached. Further experiments on this point might throw fresh light upon the problem, in which event, of course, the theses advanced in this direction by Mr. Strutt would require modification.

Although at first sight it seems incredible that the earth's crust should be so comparatively thin as 45 miles, yet it is noteworthy to remark that the investigations carried out by the eminent seismologist, Prof. Milne, as a result of his study of the velocity of the propagation of earthquake waves through the earth, substantially support this calculation. Prof. Milne estimates the thickness at thirty miles, which is quite consistent with the foregoing data, if rocks like granite, rich in radium, are in greater abundance than Mr. Strutt has assumed in taking the value of 5×10^{-12} gramme radium per cubic centimeter as representative. Prof. Milne is of opinion that a fairly abrupt transition occurs at a depth of 30 miles and that the material below that depth is fairly uniform through the globe, in which thesis he is entirely in agreement with Mr. Strutt's view of the earth's interior.

As to the chemical composition of the nucleus in the earth's interior, this is somewhat complex to determine. Investigations point to the fact that it scarcely consists principally of iron, as is generally supposed from the analogy of meteorites, since the iron of the latter is remarkable on account of its freedom from radium. On the other hand, if the stony exterior of the earth is but a small fraction of the entire volume, it cannot exercise much influence on the mean density, which should be nearly equal to that of the core. Furthermore, the density of the earth, which is 5.5, is much less than the density of iron, which is 7.7.

The results of these investigations of the structure of the earth have an interesting application in regard to the moon. Observation of the moon's surface points to the fact that it consists of rock similar to that on the earth, and as the moon is generally believed to have originally constituted a part of the earth it should therefore consist of the same material. Moreover, the density of the moon, which is 3.5, does not differ very appreciably from that of rock.

On the understanding that the rocks of the moon are closely allied to those found on the earth, the temperature gradient of the former body should be very great in comparison with that of the earth. The material of the moon is taken to be some thirty times richer in radium than the mean material of the earth, while the volume is about one-fiftieth of that of the earth. On this basis, the total heat production in the moon would be about one-half of that in the earth. This heat has to flow out through about one-sixteenth the area of the surface of the earth, and consequently the temperature gradient at the moon's surface should be eight times greater than at the earth's. Gravity, moreover, is much less on the moon, so that it is quite permissible to conclude that the conditions which prevail there are far more favorable to the manifestation of the internal heat by volcanic upheaval. This explains why volcanic features are so much more prominent on the moon than on the earth. Prof. W. H. Pickering has done much to dispel the popular idea that the lunar craters are extinct and that the moon has no internal heat, since he, together with other observers who have made a close study of the moon's surface, believe in the reality of changes occurring there. Their theses moreover receive substantial support from the results of the Hon. R. J. Strutt's investigation, so that it is only reasonable to believe that the moon, far from being a dead body, possesses far greater heat than can be imagined.

RECESSION OF NIAGARA FALLS.

HORSESHOE FALL has receded more than 260 feet within the memory of living men, and is now traveling toward Lake Erie at the rate of fully 500 feet a century.

At present the crest of this fall, as its name implies, has the general outline of a horseshoe, and its length is about 3,000 feet, but if the present rate of erosion continues the length of the crest may reach 8,000 feet or more within the next half millennium. Now the Canadian end of the Horseshoe Fall is a few rods upstream from the spot whence Table Rock has fallen into the Gorge, but the indications are that this end of the cataract will gradually retire toward the Dufferin Islands, leaving a bare cliff as the apex cuts its way upstream.

The forces that are operating to bring about these changes have cut the prophecy of their completion in the rock of the river bed. In the earliest known view of Niagara Falls, that of Father Hennepin, published in 1697, the crest of what is now the Canadian cataract, like that of the American, is a straight line. Draw such a line from the spot where the crest of the Horseshoe Fall touches Goat Island, and across the Gorge at right-angles to the Canadian bank of the river, and you have the probable approximate location of the crest of the greatest of the three cataracts that Hennepin saw. During the more than three centuries since Hennepin and La Salle first looked on this "great and prodigious cadence of waters," what is now the American Falls seems to have changed but little. Meantime the relatively small cataract, that the picture made by Hennepin shows in front of and flowing at right angles to the Horseshoe Fall, has disappeared so long ago that no living man can remember it, and the latter fall has so changed that Hennepin himself would hardly recognize it if he came back.

The straight line across Niagara Gorge, mentioned above as the probable location of the Horseshoe Fall in the time of Hennepin, measures nearly 1,300 feet from cliff to cliff. From the main New York bank along the crest of the American Fall to Luna Island, a mass of rock that is separated from Goat Island by a slender stream of water, the distance is only 800 feet in a straight line. The picture given by Hennepin shows no break in the crest of the American Fall between the New York bank and Goat Island, and it seems most probable that Luna Island was then a part of the former. With 800 and 1,300 feet, respectively, for the widths of the two larger cataracts seen by Hennepin, his picture of the Falls is very nearly in accord. All this is some evidence that the crest of the Horseshoe Fall in the time of Hennepin was approximately a straight line from the down-stream end of Goat Island to the Canadian bank. From the center of such a line to the present apex of Horseshoe Falls the distance is about 1,300 feet, and so it appears that the fall has receded to this extent during something more than three centuries.

Conclusions based on the apparent size and form of the Falls in the picture of Father Hennepin are in the nature of the case uncertain, but later and more accurate information leads to similar results.

In 1842, the contour of the Horseshoe Fall was determined by the State Geologist of New York, and, in 1890, the contour was again determined by the New York State Engineer. During the forty-eight years between these dates the crest of the Horseshoe Fall at its apex receded some 260 feet upstream. In this recession the apex of the Fall moved not in a straight line, but on a curve, as it had apparently done before, and maintained a nearly constant distance from Goat Island, while receding from the Canadian bank. As located in 1890, the apex of the Fall was about 1,300 feet from the nearest point on the shore of Queen Victoria Niagara Falls Park, and some 700 feet from the bank of Goat Island. If the apex of the Fall continues to cut its way upstream during the next 500 years at the same rate it has gone since 1842, and follows about the same curve, the year 2400 will see it some 2,500 feet nearer Lake Erie, and between the Three Sisters and Little Brother Island on the one side, and the Dufferin Islands on the other. From Little Brother Island the apex of the Fall will then be distant probably 700 feet, or 1,400 feet from Goat Island, and some 2,100 feet from the Dufferin Islands. In order to understand the reasons for the past and probable future movements of the crest of Horseshoe Fall, it is necessary to consider the forces by which the strong hand of the waters is chiseling a narrow channel several hundred feet deep through the strata of rock that underlie the upper river.

Just above Goat Island the width of Niagara River is more than 4,000 feet; between the upper end of the island and the Canadian bank the width is about 3,300 feet; and across the Gorge on a line uniting the ends of the Horseshoe Fall the distance is 1,200 feet. Approximately nine-tenths of the 222,000 cubic feet of water discharged by Niagara River per second is thus crowded into a deep and narrow channel before it reaches the Horseshoe Fall. Along what was supposed to be the deepest part of this channel runs the boundary line between the United States and Canada, fixed by the treaty of Ghent at the close of the war of 1812. Curiously enough at first sight, but for a very good reason, this boundary line coincides nearly with the center of the boiling cañon between the two converging sides of the Horseshoe Fall, and passes 300 feet from its apex. Such is the nature of the bed of the upper Niagara River that the erosion along the crest of the Fall increases very rapidly with the depth of the water. This is due to the fact that all of the more rapid erosion takes place not by the gradual wear of the silt and gravel carried by the water, but by the breaking of great chunks of rock from the river bed.

At the bottom of Niagara River, just above the Falls, there is a layer of hard limestone intersected by numerous seams, and below this are layers of shale and other soft rock to a depth of several hundred feet. The limestone crest wears away only slowly as the water rushes over it, but the shale underneath is rapidly disintegrated by the spray and back-wash, so that the face of the cliff behind the Falls is constantly concave. It is this formation that makes it possible to go behind both the American and the Horseshoe Fall. As the overhanging ledge of brittle limestone is thus constantly increasing in length, a point is frequently reached near the apex of the Horseshoe Fall where the great depth and weight of water overhead can no longer be supported, and a large block of the projecting rock breaks off. In this way is the Horseshoe Fall cutting a gorge upstream, and the overhanging limestone naturally breaks away faster and forms the apex of the Fall at the point where the water is deepest and its weight the greatest. Hence, the form of the Horseshoe Fall. At the crest of the American Fall the water is shallow, for it forms only about one-tenth of the entire discharge of the Niagara River, and the channel between Goat Island and the New York bank, about 1,800 feet above the Fall, has a minimum width of only 400 feet, while the clear crest of the Fall is about 1,000 feet long. These conditions, together with the approximately uniform depth of water along the crest of the American Fall, have kept it nearly a straight line, and made its recession very slow.

It now remains to determine some of the results that will probably follow as the apex of the Horseshoe Fall travels toward the first line of breakers some 3,000 feet above the present crest. Niagara River changes its direction by fully ninety degrees at the Horseshoe Fall, and the Gorge just below is gradually being cut to form the arc of a circle, much as that at the Whirlpool was many centuries ago.

When Father Hennepin, in 1679, first saw Niagara, the Horseshoe Fall was just about to begin to make this 90-degree turn; its crest line seems to have been nearly straight, and its probable length was about 1,300 feet, as indicated above. Now the recession of the Falls has more than doubled that length of crest line, by changing it into the horseshoe form, and as the process goes on a long gorge not more than 700 feet wide will be cut in that part of the river bed where the water is the deepest. Thus the edge of the cliff over which the water flows will constantly lengthen, and the average depth of water over the edge of that cliff will approach more nearly to the greatest depth in that part of the river between Goat Island

and the Canadian bank. As the volume of water per second that will flow over the edge of the cliff depends on the length of that edge, and on the depth of water above it, and as the actual discharge of the river may be assumed to be constant for this purpose, it follows that the water level between Goat Island and Queen Victoria Niagara Falls Park will be much lowered within the next five centuries. Even the coming century, if the apex of the Horseshoe Fall recedes 500 feet meantime, will see the crest of this fall increased by 1,000 feet, or one-third of its present length, and the water level between Goat Island and Queen Victoria Park will probably be reduced by one to several feet. Before the apex of the Falls reaches a point between Little Brother Island and the Dufferin Islands, the water flowing in front of Queen Victoria Park will be so thin a sheet that it will make nothing but spray in going over the edge of the cliff.

When the Horseshoe Fall has a crest some 8,000 feet long into a gorge that measures 3,500 feet from the apex of the Fall to its lower ends, and not more than 700 feet across between the two facing wings of the cataract, it will present an even more interesting spectacle than it does to-day.

Another incident of this change will be its effect on the great power plants between Dufferin Islands and the present crest of the Fall, along the shore of Queen Victoria Park. Directly in front of and only 700 to 1,000 feet distant from these plants will then be the crest of the Fall, and a great reduction of the water level at their intakes must result. The present stockholders and bondholders in these plants need not be alarmed, however, for long before the changes mentioned can be completed much of the equipment of these plants will have sunk in rust, after having earned, it is hoped, at least a fair return.

THE MORTON MEMORIAL LABORATORY OF CHEMISTRY OF STEVENS INSTITUTE OF TECHNOLOGY.*

By PROF. F. J. POND, A.M., Ph.D., Assistant Professor of Engineering Chemistry, Stevens Institute of Technology.

THE laboratory, which is certainly one of the finest of its type in this country, is very conveniently situated with respect to the other institute buildings. The plot of ground upon which the building stands is a part of the new tract of land secured by the institute on the Castle Point grounds, Hoboken, N. J. One of the most important conditions affecting the usefulness of a chemical laboratory is a proper provision for apartments abundantly lighted. In this respect the location was wisely selected, since all of the rooms are well lighted and the large student laboratory is especially well provided for in this respect by receiving light from both the north and the south. The building is without a basement and consists of three stories, the attic above the third floor remaining in the rough and being utilized for storage, and as a space for ventilating pipes, and for installing a small fan for ventilating the hoods in the lecture room. All rooms are so connected as to be easily accessible, and are of the size and shape best adapted to the special purposes for which they are intended.

The entrance from River Street leads to a lobby, from which a wide corridor extends through the building to the rear doors. On the right of the corridor are a toilet room, oil and gas-analysis room, coatroom, janitor's room, assay room with its smaller balance room, electrochemical laboratory, and main stock room, the latter being conveniently placed near to the rear doors for receipt of chemicals and apparatus. The stock room is connected by a stairway with a supply room on the second floor, and is provided with a lift. On the left of the corridor are the professor's office, his private laboratory and balance room, assistant professor's private laboratory, and machinery or fan room. From the lobby at the front of the building an iron stairway with slate steps leads from the first floor to the second or main laboratory floor; beneath the stairway and extending a few feet below the first floor level is a large fire-proof vault for preserving institute records, etc. The stairway from the first floor leads to a lobby on the second floor, from which the large analytical laboratory, designed for both qualitative and quantitative analysis, is entered; this laboratory with its combustion or ignition room, hydrogen sulphide room, supply room, and balance room on a mezzanine floor, occupies the entire second story. A second stairway leads from the lobby on the second floor to a corridor on the third floor, which extends to the lecture room in the northeasterly end of the building. On the right of the corridor are a toilet room, office, library, and lecture preparation room; the last-named room is connected with the second-floor supply room and the first-floor stock room by the lift already mentioned, and with the lecture room by a door and two hoods which extend through the partition. Speaking tubes extend from each floor to the stock room. A stairway also leads from the preparation room to the unfinished space above the third floor. All the rooms on the right of the third floor corridor are comparatively narrow, while on the left are a large recitation room, the Morton Memorial room, and a narrow corridor leading to an unfinished but large storeroom and workshop under the lecture room seats. The large lecture room with its preparation room occupies all of the easterly end of this floor.

VIEW OF MAIN LABORATORY LOOKING TOWARD BALANCE ROOM.

VIEW OF MAIN LABORATORY LOOKING FROM BALANCE ROOM.

THE MORTON MEMORIAL LABORATORY OF CHEMISTRY OF STEVENS INSTITUTE OF TECHNOLOGY.

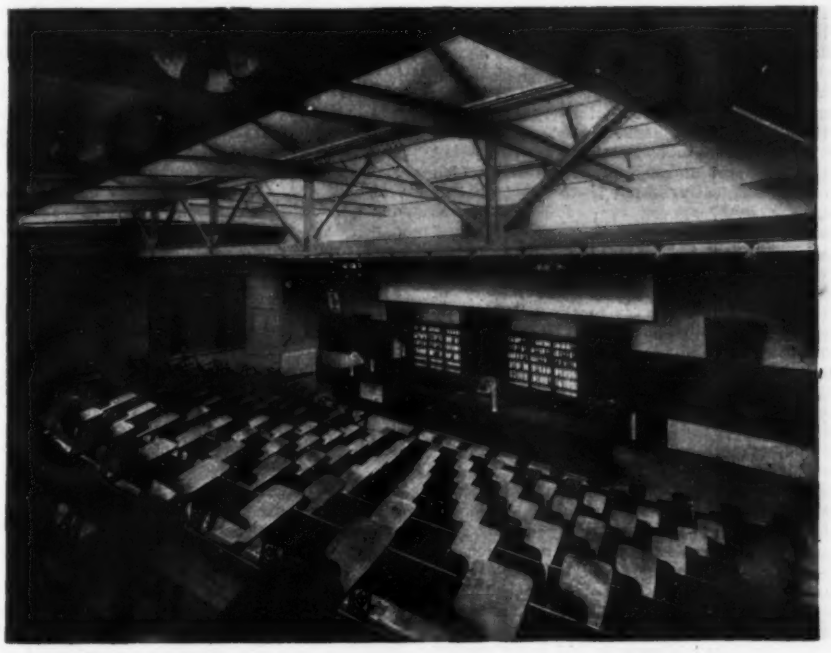
The building, with its fixtures, was planned by a committee from the institute faculty with Prof. D. S. Jacobus as its chairman, and the plans were finally carried out by Messrs. Ackerman & Partridge, architects, of New York. The building was erected between March, 1905, and February, 1906, at a cost of about $150,000.

In the construction of the building, the chief consideration was for its practical utility, and the architects have succeeded in combining this with a pleasing architectural effect. The exterior walls are built of red, hard-burned bricks with raked joints, upon a granite base; the trimmings are of limestone, and the steps leading to the buildings are of granite. The structure is built throughout on the principles of fire-proof construction, the building materials being steel, brick, and cement, with stone trimmings; the interior walls and partitions are laid with buff-colored brick, with a base three courses high of red pressed brick. The windows are large and well distributed so as to afford an abundance of light. Doors, working tables, shelves, and, in fact, all of the woodwork in the building, except a few floors, is of quartered oak having a dark finish. The floors throughout the building have a reinforced cement base; in the laboratories and preparation room the floors are of asphalt, while the lecture room, recitation room, library, balance rooms, and offices have floors of maple. All ceilings except those of the memorial, lecture, and recitation rooms are of cement.

The heating and ventilating system was designed and installed by Mr. A. R. Wolff. The heating is effected by steam radiators placed in the various rooms, the steam being supplied from the boiler house of the Carnegie Laboratory of Engineering, which furnishes steam for all of the institute buildings. The radiators are placed under the windows or close to the exterior walls. The steam supply pipe, together with the electrical leads, etc., pass from the power house to the building through a tunnel especially constructed for this purpose. The ventilation of all the rooms is by positive air pressure, produced by a large blower on the first floor. The fresh air is taken from the north side of the building, filtered through cloth, and is then compressed in the air chamber by the blower, which is connected with an electric motor. The air then passes through suitable flues to registers placed near the ceilings of the various rooms. In the winter months the air is heated by passing through steam coils in chambers in the fan room. The vitiated air and fumes, generated in chemical work in the main laboratory and other rooms on the second floor, escape through a system of individual hoods with down draft, designed by Prof. Jacobus. The exhaust supplied by the exhauster on the first floor to each hood amounts to about 175 cubic feet of air per minute. The fumes pass through the hoods and then downward through vertical tile pipes into large tile ducts suspended from the ceiling of the first floor. These ducts are in turn connected with the large exhauster driven by a 16-horse-power electric motor. This system of ventilation proves so efficient that with a class of ninety-six students all working at qualitative analysis, some with concentrated hydrochloric acid and others close by with concentrated ammonium hydroxide, the atmosphere remains perfectly clear and the fumes formed cannot be detected a few seconds after they are generated. This system of ventilation is, to the writer's knowledge, the first of its type to be attempted on a large scale and with the large volume of air which is drawn through the hoods as above specified, and a special feature of this system is that it works equally well with the windows open or closed. In the hydrogen sulphide room, leading from the main laboratory, are sixteen closed hoods with glass doors; these hoods are also connected with the down-draft system, and so efficiently does it do its work that with twelve or fif-

* Stevens Institute Indicator.

teen students all precipitating solutions with hydrogen sulphide gas, practically no odor of the gas can be detected in the room, even when some of the students fail to close the doors of the hoods. The results so far obtained in this laboratory seem to demonstrate very conclusively that this system of ventilation is vastly superior to any other which has been put into practical application in a large laboratory with classes



LECTURE ROOM.

of ninety to one hundred students. The vitiated air from the rooms on the first floor, as well as fumes generated in the hoods in the private laboratories on this floor, escape through ventilators placed in the chimney flues. The foul air from the rooms on the third floor passes through registers placed in the walls near the floor and through ducts to a ventilator in the roof of the building; in this ventilator is a horizontal exhaust fan driven by a one-horse-power electric motor. The lecture-room hoods are exhausted by a Sturtevant blower connected with a 2-horse-power C. and C. motor placed in the space above the third floor.

All of the rooms in the building are equipped with gas burners for illuminating purposes. All lecture tables, working tables, etc., are fitted with gas fixtures for Bunsen burners; there are about 300 such gas fixtures. The gas enters the building from River Street through two gas meters placed in the toilet room on the first floor. Water enters the building through a No. 5 Crown water meter from River Street on the southwest corner of the building. From the meter the water passes through wrought-iron pipes 3 inches in diameter which are suspended from the ceiling of the first floor; vertical pipes then take it to the outlets in the various rooms, there being 169 water attachments in the building. The waste pipes from the sinks are of tile and are connected to horizontal cast-iron pipes which are suspended below the ceiling. The cast-iron pipes are 4 inches in diameter and are lined with pitch; these pipes are trapped and empty into the main vertical drain pipe in the first-floor toilet room, which in turn leads to the sewer. Arrangements are provided so that the waste pipes from the main laboratory may be flushed at any time with large quantities of water; the flushing water is admitted directly into the horizontal cast-iron waste pipes and its quantity is controlled by automatic valves in the supply room leading off the main laboratory. The sinks, forty-eight in number, are of special construction to avoid water being splashed from them, and are of earthenware or of Alberene stone. All pipes for gas, steam, water, and drainage, as well as the large tile pipes for conducting the waste gases from the hoods, are suspended from the ceilings, and every joint and length of pipe is perfectly accessible so that any leak may be readily detected and repaired. All pipes are painted with aluminium paint. As a protection against fire there are three sets of hose, one on each floor, connected with special water pipes and ready for instant use. There are also small hand fire extinguishers placed in the various rooms. A fire escape is built on the center of the north side of the building, with platforms communicating with the lecture room and main laboratory. The electricity used in the building is obtained from the Carnegie Laboratory of Engineering. The motors require 22 horse-power. All rooms are furnished with electric lights, of which there are 436 of 16 candle-power and twenty-eight of 8 candle-power. The electrical lighting system is controlled from three switchboards, placed in the toilet room on the first floor, in the lobby of the second floor, and the corridor of the third floor, respectively. In the janitor's room on the first floor is a telephone connected with a private central in the Carnegie Laboratory of Engineering. The lift connecting the main stock room on the first floor with the second and third floors is of the dumbwaiter type and is raised and lowered by hand. Distilled water is conducted to the rooms in which it is needed by tin-lined iron pipes. The faucets have self-closing cocks, and are silver plated in all parts where contamination might take place. All working tables, shelves, and cabinets rest on a coved cement base two and a half inches high, to prevent liquids from flowing under them.

The institute provides a broad course in engineering, and the chemistry included in this course is such as to meet the requirements of the educated engineer; consequently, many rooms, such as an organic chemistry laboratory, a physiological chemistry room, an agricultural chemistry room, etc., which are essential parts of many college laboratories of chemistry, would be superfluous here. Chemistry is studied by all students during the first three years. The classroom work consists of a course of lectures and recitations on general chemistry, followed by a course of lectures and recitations on the chemistry of the materials of engineering, and the metallurgy of iron and steel. The laboratory work commences with qualitative analysis and is continued with a course in quantitative analysis. The Morton Memorial Laboratory of Chemistry was therefore planned to afford the best accommodations possible for students in the chemical subjects as above outlined, and no space has been given for rooms which would be of little or no value for the regular scheduled work.

NEW COAL MINE EXPLOSIVE.

IT is well known that as coal-mining operations progress and the mines become deeper, inflammable gas is usually more frequently encountered, ventilation becomes more difficult, and the danger of firedamp explosions is greatly increased. The number of accidents occurring from the ignition of inflammable gas mixtures and coal dust, both from miners' lamps and from powder blasts, has led to the invention of a number of devices beginning with the Davy safety lamp, designed for the purpose of decreasing the danger of the miners' lights igniting the gas. This was followed more recently by the introduction of so-called "safety explosives," which are of such character as to reduce the frequency of the gas and dust mixtures becoming ignited in the operation of blasting.

In England, the subject of prevention of mine explosions comes under the authority of two branches of the government, the inspectors of mines and the inspectors of explosives. The former are doing all in their power to secure the safety of the miners by framing regulations designed to control the methods of working and ventilation, and to prevent the accumulation of dust and gas; while the inspectors of explosives decide finally whether or not any explosive shall be permitted in gaseous or dusty mines. Work on similar lines has been carried on by the governments of various continental European countries—notably, Belgium, France, and Germany, special stress being laid on the explosives themselves, and their freedom from liability to ignite gases and dusty mixtures. A number of explosives have been put on the market in Europe and used more or less successfully in gaseous mines for a number of years, although nearly all of these have produced an explosion of gas or dust at one time or another. Therefore, it cannot be said of any explosive that it is absolutely flameless, as the temperature of the resultant gases must necessarily be so high as to produce incandescence and flames, and the firing of an over-charged bore hole will nearly always ignite gas, no matter how safe the explosive may be.

There are two methods, broadly speaking, of making a safety, or so-called "flameless," explosive. One depends upon the incorporation with a nitro-glycerine explosive of certain salts containing water of crystallization, such as alum, which serves to drown the flame produced by the other explosive ingredients. This method, unfortunately, requires a considerable proportion of the strength of the explosive to convert this water into gas. The other class of "flameless" powders depends upon the fact that several ingredients produce a comparatively low temperature on detonation. Since the products of their complete decomposition are, in theory at least, entirely gaseous, there can be no masses of solid matter raised to incandescence from the explosive itself, thus retaining the heat of explosion long enough to ignite the gas mixture. These explosives are practically incombustible and develop power only on detonation. Practically all of the safety explosives for use in gaseous mines in Europe belong to this latter class, of which bellite, roburite, and ammonite may be mentioned as examples. Unfortunately, nearly all explosives of this class hitherto placed on the market are very difficult to detonate completely, and it is upon the sudden and complete detonation of the powder, which prevents any burning or glowing particles from being projected from the bore hole, that the safety of the explosive, to a great extent, depends. Mining operations in this country are generally regulated by the different States, through their mine inspectors. These officials are generally selected from practical miners or mine officials of long experience after a competitive examination, and while they have not the power of the corresponding authorities in Europe, they can make suggestions and recommendations which have great weight with the mine owners. In several cases they have practically prohibited the use of black powder, and even dynamite in certain gaseous mines, on account of the danger of the flame from the blast causing a gas explosion.

WORKING TABLE, SHOWING INDIVIDUAL HOODS.

THE MORTON MEMORIAL LABORATORY OF CHEMISTRY OF STEVENS INSTITUTE OF TECHNOLOGY.

Until a comparatively recent date, coal-mining operations in the United States had not reached a depth or an extent where gas was encountered in such quan-

tities as to make apparent the necessity for the use of safety explosives. Now, however, such a necessity has appeared in many of the coal fields in this country, as evidenced by the number of disasters attributed to both gas and dust, which have often justly or unjustly been laid at the door of the blasting agent in use in the mine. It must be borne in mind that the safest explosive may become dangerous when loaded in an improperly placed bore hole, in too large a charge, or insufficiently tamped; while on the other hand the expert blaster is often able to use an inferior explosive for a long time without accident by exercising care and judgment in locating, loading, and tamping his shot holes. For the use of the common run of miners, the owners generally prefer that explosive which is least liable to bring about a disaster, in whatever manner it may be used.

To meet the demand of miners conducting operations in the presence of gas for an explosive which would minimize the danger of igniting gas and dust mixtures from the blasting operations, a new explosive has recently been invented, named nyalite, manufactured by the Du Pont Company. This belongs to the detonating class of explosives; but not to the variety in which the effect of the flame-producing ingredients is nullified by another ingredient which acts as a drag on the rest. In nyalite the miner has an explosive, each ingredient of which is incorporated with the definite purpose of producing complete detonation and the greatest rupturing power possible, at the lowest temperature, and with the smallest quantity of flame. This explosive has been used in constantly-increasing quantities during the few months that it has been on the market. It has been tested by State mine inspectors in the presence of gas, and has successfully passed every test for safety and efficiency which has been devised either by State authorities or mining officials.

Although nyalite belongs to the class known as high explosives, as distinguished from black powder, it has more of the heaving or pushing action of the latter, without the shattering and pulverizing effect of dynamite. This peculiarity is of great value in coal mining, especially in those mines where the product is desired in lumps rather than in slack. About one-third as much nyalite in weight as of black powder has given good results in actual practice. Owing to the fact that nyalite is always completely detonated, there is a marked absence of offensive fumes and smoke resulting from its use, which means a minimum loss of time to the miner in returning to his work after the blast and increased production of coal in the mine. It does not freeze, does not lose its sensitiveness or deteriorate with age, requires no special manipulation, and cannot be exploded except by means of a detonating cap. Many years of research and experiment were devoted to the perfection of nyalite, and while it is necessarily a specialty and designed only for use in mining coal, in this branch of industry it leaves very little to be desired. It is loaded, primed, tamped, and fired in the same manner as any high explosive, and in the hands of miners with ordinary intelligence has never failed to give satisfactory results.—Mines and Minerals.

[Continued from SUPPLEMENT No. 1600, page 25635.]

THE INCREASE OF KNOWLEDGE IN THE SEVERAL BRANCHES OF SCIENCE.*

By PROF. E. RAY LANKESTER, M.A., LL.D., D.Sc., F.R.S., F.L.S.

ANOTHER great area of exploration and source of new things has been the southern part of Argentina and Patagonia, where Ameghino, Moreno, and Scott, of Princeton, have brought to light a wonderful series of extinct ant-eaters, armadilloes, huge sloths, and strange ungulates, reaching back into early Tertiary times. But most remarkable has been the discovery in this area of remains which indicate a former connection with the Australian land surface. This connection is suggested by the discovery in the Santa Cruz strata, considered to be of early Tertiary date, of remains of a huge horned tortoise which is generically identical with one found fossil in the Australian area of later date, and known as Miolania. In the same wonderful area we have the discovery in a cave of the fresh bones, hairy skin, and dung of animals supposed to be extinct, viz., the giant sloth, Mylodon, and the peculiar horse, Onohippidium. These remains seem to belong to survivors from the last submergence of this strangely mobile land-surface, and it is not improbable that some individuals of this "extinct" fauna are still living in Patagonia. The region is still unexplored and those who set out to examine it have, by some strange fatality, hitherto failed to carry out the professed purpose of their expeditions.

I cannot quit this immense field of gathered fact and growing generalization without alluding to the study of animal embryology and the germ-layer theory, which has to some extent been superseded by the study of embryonic cell-lineage, so well pursued by some American microscopists. The great generalization of the study of the germ-layers and their formation seems to be now firmly established—namely, that the earliest multicellular animals were possessed of one structural cavity, the enteron, surrounded by a double layer of cells, the ectoderm and endoderm. These Enterocœla or Cœlentera gave rise to forms having a second great body-cavity, the cœlom, which originated not as a split between the two layers, as was supposed twenty-five years ago by Haeckel and Gegenbaur and their pupils, but by a pouching of the enteron to form one or more cavities in which the reproductive cells should develop—pouchings which became nipped off from the cavity of their origin, and formed thus the independent cœlom. The animals so provided are the Cœlomocœla (as opposed to the Enterocœla), and comprise all animals above the polyps, jelly-fish, corals, and sea-anemones. It has been established in these twenty-five years that the cœlom is a definite structural unit of the higher groups, and that outgrowths from it to the exterior (cœlomoducts) form the genital passages, and may become renal excretory organs also. The vascular system has not, as it was formerly supposed to have, any connection of origin with the cœlom, but is independent of it, in origin and development, as also are the primitive and superficial renal tubes known as nephridia. These general statements seem to me to cover the most important advance in the general morphology of animals which we owe to embryological research in the past quarter of a century.*

Before leaving the subject of animal morphology, I must apologize for my inability to give space and time to a consideration of the growing and important science of anthropology, which ranges from the history of human institutions and language to the earliest prehistoric bones and implements. Let me therefore note here the discovery of the cranial dome of *Pithecanthropus* in a river gravel in Java—undoubtedly the most ape-like of human remains, and of great age; and, further, the Eoliths of Prestwich, in the human authorship of which I am inclined to believe, though I should be sorry to say the same of all the broken flints to which the name "Eolith" has been applied. The systematic investigation and record of savage races have taken on a new and scientific character. Such work as Baldwin Spencer's and Haddon's in Australasia furnish examples of what is being done in this way.

Physiology of Plants and Animals.—Since I have only time to pick the most important advances in each subject for brief mention, I must signalize in regard to the physiology of plants the better understanding of the function of leaf green or chlorophyll due to Pringsheim and to the Russian Timiriaseff, the new facts as to the activity of stomata in transpiration discovered by Horace Brown, and the fixation of free nitrogen of living organisms in the soil and by organisms (*Bacillus radicola*) parasitic in the rootlets of leguminous plants, which thus benefit by a supply of nitrogenous compounds which they can assimilate.

Great progress in the knowledge of the chemistry of the living cells or protoplasm of both plants and animals has been made by the discovery of the fact that ferments or enzymes are not only secreted externally by cells, but exist active and preformed *inside* cells. Büchner's final conquest of the secret of the yeast-cell by heroic mechanical methods—the actual grinding to powder of these already very minute bodies—first established this, and now successive discoveries of intracellular ferments have led to the conclusion that it is probable that the cell respires by means of a respiratory "oxydase," builds up new compounds and destroys existing ones, contracts and accomplishes its own internal life by ferments. Life thus (from the chemical point of view) becomes a chain of ferment actions. Another most significant advance in animal physiology has been the sequel (as it were) of Bernard's discovery of the formation of glycogen in the liver, a substance not to be excreted, but to be taken up by the blood and lymph, and in many ways more important than the more obvious formation of bile which is thrown out of the gland into the alimentary canal. It has been discovered that many glands, such as the kidney and pancreas and the ductless glands, the suprarenals, thyroid, and others, secrete indispensable products into the blood and lymph. Hence myxœdema, exophthalmic goitre, Addison's disease, and other disorders have been traced to a deficiency or excess of internal secretions from glands formerly regarded as interesting but unimportant vestigial structures. From these glands have in consequence been extracted remarkable substances on which their peculiar activity depends. From the suprarenals a substance has been extracted which causes activity of all those structures which the sympathetic nerve system can excite to action; the thyroid yields a substance which influences the growth of the skin, hair, bones, etc.; the pituitary gland, an extract which is a specific urinary stimulant. Quite lately the mammalian ovary has been shown by Starling to yield a secretion which influences the state of nutrition of the uterus and mammæ. Had I time, I might say a great deal more on topics such as these—topics of almost infinite importance; but the fact is that the mere enumeration of the most important lines of progress in any one science would occupy us for hours.

Nerve-physiology has made immensely important advances. There is now good evidence that all excitation of one group of nerve-centers is accompanied by the concurrent inhibition of a whole series of groups of other centers, whose activity might interfere with that of the group excited to action. In a simple reflex flexure of the knee the motorneurones to the flexor muscles are excited, but concurrently the motorneurones to the extensor muscles are thrown into a state of inhibition, and so equally with all the varied excitations of the nervous system controlling the movements and activities of the entire body.

The discovery of the continuity of the protoplasm through the walls of the vegetable cell by means of connecting canals and threads is one of the most startling facts discovered in connection with plant-structure, since it was held twenty years ago that a fundamental distinction between animal and vegetable structure consisted in the boxing-up or encasement of each vegetable cell-unit in a case of cellulose, whereas animal cells were not so imprisoned, but freely communicated with one another. It perhaps is on this account the less surprising that lately something like sense organs have been discovered on the roots, stems, and leaves of plants, which, like the otocysts of some animals, appear to be really "statocytes," and to exert a varying pressure according to the relations of these parts of the plant to gravity. There is apparently something resembling a perception of the incidence of gravity in plants which reacts on irritable tissues, and is the explanation of the phenomena of geotropism. These results have grown out of the observations of Charles Darwin, followed by those of F. Darwin, Haberlandt, and Nemec.

A few words must be said here as to the progress of our knowledge of cell-substance, and what used to be called the protoplasm question. We do not now regard protoplasm as a chemical expression, but, in accordance with Von Mohl's original use of the word, as a structure which holds in its meshes many and very varied chemical bodies of great complexity. Within these twenty-five years the "centrosome" of the cell-protoplasm has been discovered, and a great deal has been learned as to the structure of the nucleus and its remarkable staintaking bands, the chromosomes. We now know that these bands are of definite fixed number, varying in different species of plants and animals, and that they are halved in number in the reproductive elements—the spermatozoid and the ovum—so that on union of these two to form the fertilized ovum, (the parent cell of all the tissues), the proper specific number is attained. It has been pretty clearly made out by cutting up large living cells—unicellular animals—that the body of the cell alone, without the nucleus, can do very little but move and maintain for a time its chemical status. But it is the nucleus which directs and determines all definite growth, movement, secretion, and reproduction. The simple protoplasm, deprived of its nucleus, cannot form a new nucleus—in fact, can do very little but exhibit irritability. I am inclined to agree with those who hold that there is not sufficient evidence that any organism exists at the present time which has not both protoplasm and nucleus—in fact, that the simplest form of life at present existing is a highly complicated structure—a nucleated cell. That does not imply that simpler forms of living matter have not preceded those which we know. We must assume that something more simple and homogeneous than the cell, with its differentiated cell-body or protoplasm, and its cell kernel or nucleus, has at one time existed. But the various supposed instances of the survival to the present day of such simple living things—described by Haeckel and others—have one by one yielded to improved methods of microscopic examination and proved to be differentiated into nuclear and extra-nuclear substance.

The question of "spontaneous generation" cannot be said to have been seriously revived within these twenty-five years. Our greater knowledge of minute forms of life, and the conditions under which they can survive, as well as our improved microscopes and methods of experiment and observation, have made an end of the arguments and instances of supposed abiogenesis. The accounts which have been published of "radiobes," minute bodies arising in fluids of organic origin when radium salts have been allowed to mix in minute quantities with such fluids, are wanting in precision and detail, but the microscopic particles which appear in the circumstances described seem to be of a nature identical with the minute bodies well known to microscopists and recognized as crystals modified by a colloid medium. They have been described by Rainey, Harting, and Ord, on different occasions, many years ago. They are not devoid of interest, but cannot be considered as having any new bearing on the origin of living matter.

Psychology.—I have given a special heading to this subject because its emergence as a definite line of experimental research seems to me one of the most important features in the progress of science in the past quarter of a century. Thirty-five years ago we were all delighted by Fechner's psycho-physical law, and at Leipzig I, with others of my day, studied it experimentally in the physiological laboratory of that great teacher, Carl Ludwig. The physiological methods of measurement (which are the physical ones) have been more and more widely, and with guiding intelligence and ingenuity, applied since those days to the study of the activities of the complex organs of the nervous system which are concerned with "mind" or psychic phenomena. While some enthusiasts have been eagerly collecting ghost stories and records of human illusion and fancy, the serious experimental investigation of the human mind, and its forerunner the animal mind, has been quietly but steadily proceeding in truly scientific channels. The science is still in an early phase—that of the collection of accurate observations and measurements—awaiting the development of great guiding hypotheses and theories. But much has been done, and it is a matter of gratification to Oxford men that through the liberality of the distinguished electrician, Mr. Henry Wilde, F.R.S., a lectureship of Experimental Psychology has been founded in the University of Oxford, where the older studies of Mental and Moral Philosophy, Logic, and Metaphysics have so strong a hold, and have so well prepared the ground for the new experimental development. The German investigators, W. Wundt, G. E. Müller, C. Stumpf, Ebbinghaus, and Münsterberg have been prominent in introducing laboratory methods, and have determined

* Presidential address delivered to the British Association for the Advancement of Science.

* See the introduction to Part II. of a treatise on Zoology. Edited by E. Ray Lankester (London: A. & C. Black).

such matters as the elementary laws of association and memory, and the perceptions of musical tones and their relations. The work of Goldschneider on "the muscular sense," of Von Frey on the cutaneous sensations, are further examples of what is being done.

The difficult and extremely important line of investigations, first scientifically treated by Braid under the name "Hypnotism," has been greatly developed by the French school, especially by Charcot. The experimental investigation of "suggestion," and the pathology of dual consciousness and such exceptional conditions of the mind, has been greatly advanced by French observers.

The older work of Ferrier and Hitzig on the functions of the parts of the brain has been carried further by Goltz and Munk in Germany, and by Schafer, Horsley, and Sherington in England.

The most important general advance seems to be the realization that the mind of the human adult is a social product; that it can only be understood in relation with the special environment in which it develops, and with which it is in perpetual interaction. Prof. Baldwin, of Princeton, has done important work on this subject. Closely allied is the study of what is called "the psychology of groups," the laws of mental action of the individual as modified by his membership of some form of society. French authors have done valuable work here.

These two developments of psychology are destined to provide the indispensable psychological basis for Social Science, and for the anthropological investigation of mental phenomena.

Hereafter, the well-ascertained laws of experimental psychology will undoubtedly furnish the necessary scientific basis of the art of education, and psychology will hold the same relation to the art as physiology does to the art of medicine and hygiene.

There can be little doubt, moreover, of the valuable interaction of the study of physical psychology and the theories of the origin of structural character by natural selection. The relation of the human mind to the mind of animals, and the gradual development of both, is a subject full of rich stores of new material, yielding conclusions of the highest importance, which has not yet been satisfactorily approached.

I am glad to be able to give wider publicity here to some conclusions which I communicated to the Jubilee volume of the Société de Biologie of Paris in 1899. I there discussed the significance of the great increase in the size of the cerebral hemispheres in recent, as compared with Eocene mammals, and in man as compared with apes, and came to the conclusion that "the power of building up appropriate cerebral mechanism in response to individual experience," or what may be called "educability," is the quality which characterizes the larger cerebrum, and is that which has led to its selection, survival, and further increase in volume. The bearing of this conception upon questions of fundamental importance in what has been called genetic psychology is sketched as follows:

"The character which we describe as 'educability' can be transmitted; it is a congenital character. But the *results* of education can *not* be transmitted. In each generation they have to be acquired afresh. With increased 'educability' they are more readily acquired and a larger variety of them. On the other hand, the nerve mechanisms of instinct are transmitted, and owe their inferiority as compared with the results of education to the very fact that they are *not* acquired by the individual in relation to his particular needs, but have arisen by selection of congenital variation in a long series of preceding generations.

"To a large extent the two series of brain mechanisms, the 'instinctive' and the 'individually acquired,' are in opposition to one another. Congenital brain-mechanisms may prevent the education of the brain and the development of new mechanisms specially fitted to the special conditions of life. To the educable animal the less there is of specialized mechanism transmitted by heredity, the better. The loss of instinct is what permits and necessitates the education of the receptive brain.

"We are thus led to the view that it is hardly possible for a theory to be further from the truth than that expressed by George H. Lewes and adopted by George Romanes, namely, that instincts are due to 'lapsed' intelligence. The fact is that there is no community between the mechanisms of instinct and the mechanisms of intelligence, and that the latter are later in the history of the development of the brain than the former, and can only develop in proportion as the former become feeble and defective."*

Darwinism.—Under the title "Darwinism" it is convenient to designate the various work of biologists tending to establish, develop, or modify Mr. Darwin's great theory of the origin of species. In looking back over twenty-five years it seems to me that we must say that the conclusions of Darwin as to the origin of species by the survival of selected races in the struggle for existence are more firmly established than ever. And this because there have been many attempts to gravely tamper with essential parts of the fabric as he left it, and even to substitute conceptions for those which he endeavored to establish, at variance with his conclusions. These attempts must, I think, be considered as having failed. A great deal of valuable work has been done in consequence; for honest criticism, based on observation and experiment, leads to further investigation, and is the legitimate and natural mode of increase of scientific knowledge. Among the attempts to seriously modify Darwin's doctrine may be cited that to assign a great and leading importance to Lamarck's theory as to the transmission by inheritance of newly "acquired" characters, due chiefly to American palæontologists and to the venerated defender of such views, who has now closed his long life of great work, Mr. Herbert Spencer; that to attribute leading importance to the action of physiological congruity and incongruity in selective breeding, which was put forward by another able writer and naturalist who has now passed from among us, Dr. George Romanes; further, the views of De Vries as to discontinuity in the origin of new species, supported by the valuable work of Mr. Bateson on discontinuous variation; and lastly, the attempt to assign a great and general importance to the facts ascertained many years ago by the Abbé Mendel as to the cross-breeding of varieties and the frequent production (in regard to certain characters in certain cases) of pure strains rather than of breeds combining the characters of both parents. On the other hand we have the splendid series of observations and writings of August Weismann, who has, in the opinion of the majority of those who study this subject, rendered the Lamarckian theory of the origin and transmission of new characters altogether untenable, and has, besides, furnished a most instructive, if not finally conclusive, theory or mechanical scheme of the phenomena of heredity in his book "The Germ-plasm." Prof. Karl Pearson and the late Prof. Weldon—the latter so early in life and so recently lost to us—have, with the finest courage and enthusiasm in the face of an enormous and difficult task, determined to bring the facts of variation and heredity into the solid form of statistical statement, and have organized, and largely advanced in, this branch of investigation, which they have termed "Biometrics." Many naturalists throughout the world have made it the main object of their collecting and breeding of insects, birds, and plants, to test Darwin's generalizations and to expand the work of Wallace in the same direction. A delightful fact in this survey is that we find Mr. Alfred Russell Wallace (who fifty years ago conceived the same theory as that more fully stated by Darwin) actively working and publishing some of the most convincing and valuable works on Darwinism. He is still alive and not merely well, but pursuing his work with vigor and ability. It was chiefly through his researches on insects in South America and the Malay Islands that Mr. Wallace was led to the Darwinian theory; and there is no doubt that the study of insects, especially of butterflies, is still one of the most prolific fields in which new facts can be gathered in support of Darwin and new views on the subject tested. Prominent among naturalists in this line of research has been and is Edward Poulton of Oxford, who has handed on to the study of entomology throughout the world the impetus of the Darwinian theory. I must here also name a writer who, though unknown in our laboratories and museums, seems to me to have rendered very valuable service in later years to the testing of Darwin's doctrines and to the bringing of a great class of organic phenomena within the cognizance of those naturalists who are especially occupied with the problems of Variation and Heredity. I mean Dr. Archdall Reid, who has with keen logic made use of the immense accumulation of material which is in the hands of medical men, and has pointed out the urgent importance of increased use by Darwinian investigators of the facts as to the variation and heredity of that unique animal, man, unique in his abundance, his reproductive activity, and his power of assisting his investigator by his own record. There are more observations about the variation and heredity of man and the conditions attendant upon individual instances than with regard to any other animal. Medical men need only to grasp clearly the questions at present under discussion in order to be able to furnish with ease data absolutely invaluable in quantity and quality. Dr. Archdall Reid has in two original books full of insight and new suggestions, the "Present Evolution of Man," and "Principles of Heredity," shown a new path for investigators to follow.

(To be continued.)

* From the Jubilee volume of the Soc. de Biol. of Paris, 1899. Reprinted in Nature, vol. lxi., 1900, pp. 634, 635.

ROMAN TEXTILE MANUFACTURES.

WEAVING is an art of the highest antiquity. In the Vedas, VI, lx, 2, the Rishi declares that he knows "neither the warp nor the woof of religious rites." In the Iliad, the Bible, the Zendavesta, in the earliest writings of every nation of antiquity, it is distinctly described. Whether man learned it from the weaver-bird, or it grew out of platting, we know not. Its origin is plainly Oriental; and a loom of apparently the most elementary form is still used in India; and what is yet more strange, it is capable of producing the most delicate tissues known to the art. There the village weaver stretches his warp between two bamboo rollers, one of which is suspended from a tree, while the other is fastened to the earth by wooden pins driven into the turf. The earth also forms his seat, and two holes dug into it accommodate his legs. The shuttle which carries the woof is shaped like a netting-needle, and being somewhat longer than the breadth of the fabric, it is employed also as a batten, to shove the threads of the woof close up to each other.

From the Orient, the names of staples, tissues, and fabrics enable us to trace the art of weaving into Asia Minor, Egypt, and Europe. In the Augustan age the woolen industry had been established in the Levant for upward of a thousand years; the weaving of silk, both from unraveled Indian tissues, from Oriental yarns, and from the threads of native silk-worms, had been practised in the island of Cos for over 500 years. The weaving of cotton cloths belongs practically to the Alexandrian age; while the manufacture of linens in Rome was comparatively new, it having but recently been imported from Egypt. The Roman manufacture of other textiles, such as hemp, esparto, and asbestos, though interesting, was comparatively unimportant.

We are indebted to Ovid, Met. vi, 53, for an account of the woolen manufacture; dressing the wool; picking or teasing, combing, and carding it; spinning the yarn with distaff and spindle; winding, or forming the thread into clues, and dyeing. The earlier looms, like their Indian prototypes, were perpendicular, hence the warp was called *stamen* and the woof *subtemen*, and the shuttle, *radius*. The looms, the fulling-mills (for cleaning, scouring, and solidifying the cloth) and the dyeing-works, were run by water power; and although the principal works were in the city of Rome, numerous others were established in all parts of the empire, especially in Spain, Gaul, and Britain. Among the woolen fabrics were *phrygians*, a coarse shaggy cloth, made in the Asiatic provinces, and out of which the Roman tailor fashioned the brown lacerna, or great-coat, a garment with a hood, like the French military tunic of the present day. A shorter overcoat or cape, also with a hood, was called penula. It was made of a hairy cloth called *gausapa*. Another fabric called *frigus*, was like the Scotch and Irish frieze of modern times. A fabric similar to our broadcloth was called *rasa*, or smooth. *Virgata* was a striped cloth; *scutulata*, a spotted or figured tissue; *galbina*, a green or grass-colored fabric, worn by women; *palla* meant black or gray mourning-goods, etc. Among the other products of the Roman woolen looms were damasks; embroideries made on the loom, sometimes with gold and silver threads and figures; tapestries, shawls, bunting, rugs, and carpets. The bunting was used for signal flags, and for the colors carried by contestants in the chariot races. These last were organized in four companies, the Greens, Reds, Blues, and Whites; and they were championed with such *esprit de corps* and zeal that even the women became partisans, and wore silk ribbons of their favorite colors.

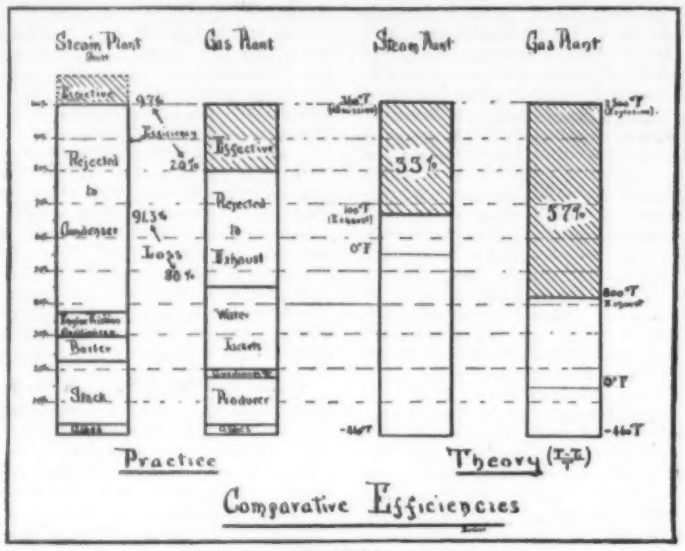
Before that great influx of the precious metals which followed the conquests of Scipio, Titus, Mummius, Lucullus, Sylla, Pompey, and Cæsar, the linen industry, like many other industries of Rome, consisted of importing the fabric from other countries, in this instance from Egypt. The culture and treatment of flax and its manufacture into a variety of fabrics had grown to considerable perfection in that country; and until Rome became a great center of capital, but feeble efforts were made to transplant this great branch of trade. With the reign of Augustus came that unity of the empire and universal peace which afforded security and assurance to its overflowing treasuries; and among the industries adopted or greatly extended was the culture of flax and manufacture of linen, either in Italy or in the Roman provinces, of which, of course, Egypt was now one. Among the various fabrics mentioned in the works which are left to us are damask tablecloths, table-napkins, and handkerchiefs, *sudaria*. A fine linen cloth from Sidon was called *sindon;* although Martial says that the same or similar stuff came also from Egypt. A twilled linen fabric, or diaper, had long been worn in Asia Minor, Egypt, and Greece. This industry was now taken up by the Romans and introduced into Italy and several of the western provinces. Linen sails for ships were also made in various parts of the empire.

The Roman costume consisted chiefly of the woolen toga and tunic; the shirt, *camisia;* and leg-cloth, *tibialia*. The overcoat, mittens, and cap, *pileus*, were only for cold weather. Of these various articles, the shirt and leg-cloth were of linen, sometimes, also, the tunic. The purple border to the toga was a survival of the purple thread of the Hindu. The latter was made from the staple of the purple cotton plant; the former was dyed with the famed murex of Tyre.

Flax was cultivated successfully in many parts of Asia Minor, including Palestine, and in most of the Greek states. Pausanias wrote that "the fine flax which is produced in Elea, is a very proper subject of admiration; for it is not to be found (in such perfection) in any other part of Greece. . . . But the fine flax (produced) within Elea is not inferior in tenuity to that of the Hebrews; while it is less yellow." After being retted in running water for about a month, it was taken out, dried, and made ready for extracting its fibers. For this purpose a bunch of it was taken in the hand, laid upon a table, and beaten with a wooden instrument. It was afterward drawn forcibly over the angle of the table, in order to free it from fragments of the stem. Then it was heckled or passed through iron combs, beginning with coarse and ending with finer ones. In this condition the fibers were free and ready for spinning into threads or yarns. The various machines and devices for retting, heckling, spinning, and weaving this staple, though derived from the older industry of hemp-manufacturing, were much improved by the Romans, who paid great attention to the details of the linen trade and exported their products to numerous places in Asia Minor and Europe.

The cotton plant and cotton fabrics are mentioned as of Indian origin by Herodotus, 450 B. C. The culture was brought westward by the followers of Alexander and Seleucus, and established in Egypt under the Ptolemies. After the battle of Actium, Egypt became a Roman province, and both the cotton fields and cotton mills of that country fell into the hands of Roman capitalists. The earlier Roman name for cotton was probably *byssus*, because its fabrics resembled linen ones, just as in England it is still called "cotton-wool," because the staple looks like bleached wool. The later Roman name was *gossypion*. *Xylon* rather meant the cotton-tree; though it was sometimes used to mean the staple. It is well known, of course, that

cotton fabrics have been found in Egyptian graves older than the Ptolemaic period; but this does not prove that they were made in Egypt, any more than a silk fabric found in an American grave of the present day would prove it to be American, the probability, amounting almost to certainty, being that it was manufactured in Europe or Asia. Cotton fabrics, however, do not appear to have become popular in Italy. The finer cotton tissues still came from India, and were very expensive; while the coarser ones were hardly so well suited to the Roman climate as linens. Before the Egyptian cotton manufacture became sufficiently improved in quality and cheapened in price to command the Italian market, it fell into the hands of the Arabians, and Rome lost the control of what was destined to become the greatest of the textile industries.



Comparative Efficiencies

FIGURE 1

Silk, though it had been imported from the Orient for many centuries, and cultivated to a small extent in some of the Greek islands, was nevertheless so scarce during the Augustan period as to command its weight in gold. The common name for it was *serica*, or *vestis serica*, sometimes *bombycina*, from *bombyx*, the silk-worm. The Roman ladies wore a broad ribbon around the waist called *strophium*, which served for the modern bodice, or stays. This ribbon or sash was made of silk. Soft clinging stuffs of silk for the *stola* were next worn; and finally the *palla* came to be made of the same expensive material. Its use was forbidden to men. Elagabalus is said to have been the first male Roman who wore a robe of pure silk; and Aurelian to have refused the empress, his wife, a garment of this fabric, on account of its exorbitant price. Yet in Pliny's time, which was much earlier, the importation of Indian silks, to be unraveled by Roman girls in order to work up the threads with woolen yarns and so to make from them new and less expensive fabrics, appears to have become an important industry; from which it would seem that stories about the parsimony of distinguished people are not always to be relied upon for historical accuracy.

Hemp is an East Indian plant which was brought into Europe probably during the first Buddhic period. Herodotus mentions a species so closely resembling flax that the Thracian women made fabrics from it which could hardly be distinguished from linen. The best hemp known to the Romans was grown at Alabanda, on the banks of the Meander, and the next best at Mylasa, near the Gulf of Jasus, both of these places being in Asia Minor. In Italy it was chiefly cultivated in the territory of the Sabines, a very ancient people. Hemp was at first employed for the ropes and rigging of ships. Moschion, about 200 B. C., records the use of hempen ropes for rigging the ship "Syracusia," built for Hiero II. some fifty years previously. Twine, hunting nets, and finally coarse fabrics, for household use, were successively made of it. The various machines and devices for retting, heckling, combing, spinning, and weaving this staple were applied to flax when that textile came to be manufactured in Rome.

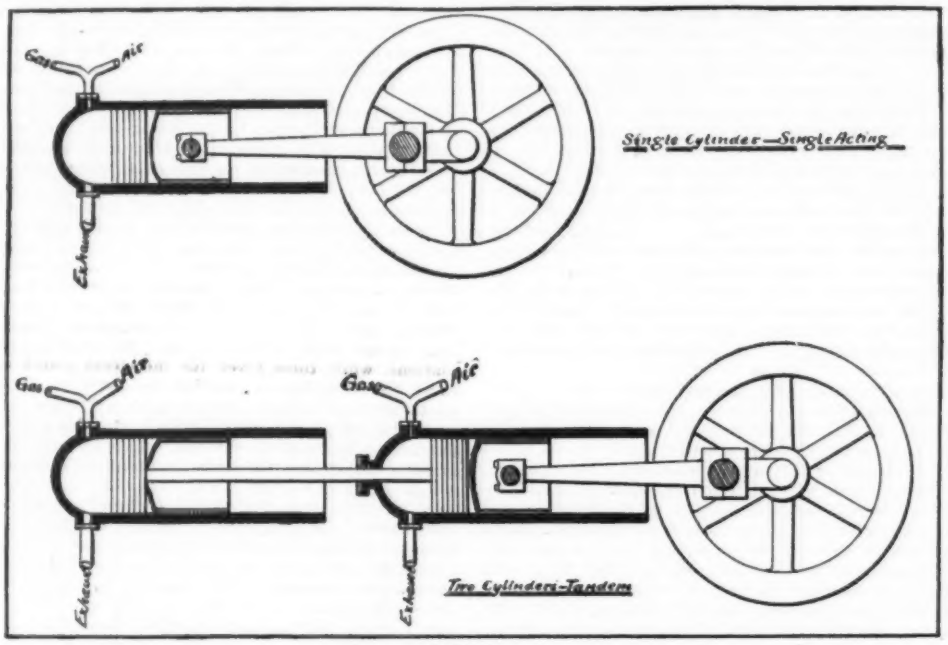


FIGURE 2

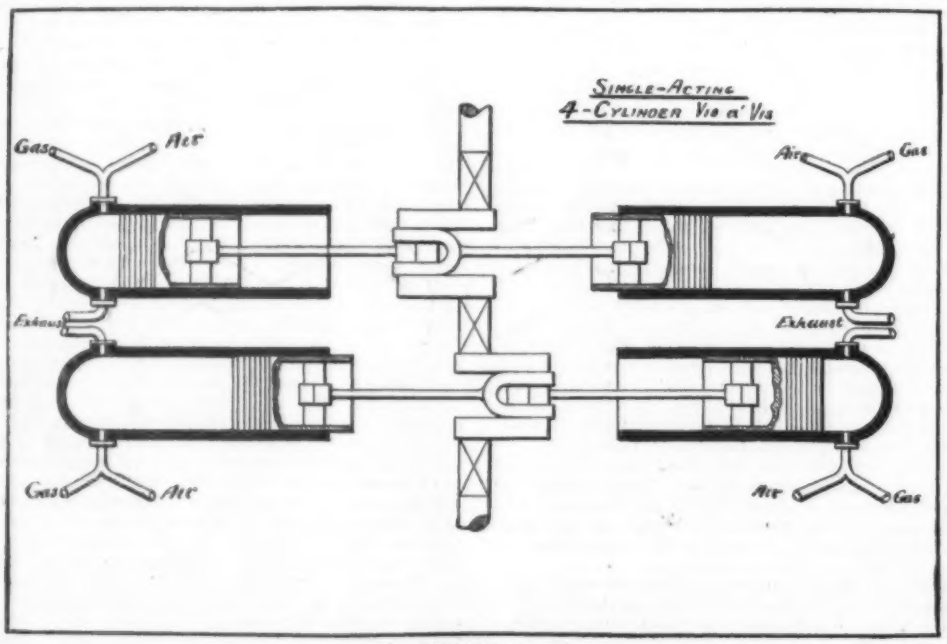


FIGURE 3

Human hair was also employed as the basis of several Roman industries, chiefly by wig-makers and jewelers. A Roman matron's wig, of a beautiful brown color, full, rich, glossy, and ending in a heavily plaited chignon, is preserved among the curiosities of the York Museum. Although 1,800 years old, it can scarcely be distinguished from a modern peruke of the most fashionable design.

The grass fibers employed by the Roman weavers, such as esparto, corn-husks, and straw, the latter for ladies' hats, were as numerous as they are at the present day. Many of them were also used for stuffing mattresses and upholstering furniture—for example, corn-husks, wool-flocks, and grasses of various sorts.

Asbestos, like many other substances which formed the bases of Roman industries, was originally obtained from India, but afterward from Arcadia. The Greeks gave it the name of *asbestinon*, which means inextinguishable; while the Romans called it *vivum*, or live (linen). They made table-napkins of it, which could be cleansed during the meal, by throwing them for a minute or so into the fire. Shrouds for the dead were also made of this substance, though it was so excessively dear that only the wealthiest people could afford to purchase it. In the year 1702 there was dug up near the Nævian Gate at Rome a funeral urn, in which human remains of the classical period were found wrapped in asbestos cloth, many yards in length. This interesting example of Roman textile art is still preserved in the Museum of the Vatican.

FUNDAMENTAL PRINCIPLES OF GAS ENGINES AND GAS PRODUCERS.*

By ROBERT T. LOZIER.

THE first question that occurs to one entering the gas-engine subject is perhaps the following:

Do steam engines and gas engines belong to the same general class? They do in so far as they are both heat engines, which depend for their operation upon that well known principle which Prof. Rankin covers in the definition he gives of the first law of thermo-dynamics as follows: "It is a matter of ordinary observation that heat, by expanding bodies, is a source of mechanical energy." That is to say, if we take a cylinder containing a charge of fluid against which rests a piston, and apply heat to the cylinder, the expansion will push the piston out, and make it do work. This fluid may be steam, or gas, or air, etc. So that in this respect gas engines and steam engines are the same, in that they are both heat engines. In what respect then does a gas engine vary from a steam engine? The answer is that with the steam engine the fuel is burned in the fire box of a boiler, located apart from the engine, while with the gas engine, the fuel is burned directly in the engine cylinder. In the case of the steam engine, we find that much of the heat of the fuel is wasted in changing water from its liquid state into a vapor that will expand and give pressure as the temperature is raised. This heat so used is called latent heat, and consumes nine hundred and sixty-six British thermal units, to change one pound of water into steam. Then again, in order to transmit the steam to the engine it must be kept down in temperature so that the pressure can be confined by the steam pipe lines and their fittings. With a gas engine, the gas may be transmitted to the engine at practically atmospheric pressure and temperature. Its heat is not developed until it is safely within the engine's cylinder, which is the exact point where the work is to be performed, and where it is fired. Therefore, gas engines are called "internal combustion engines."

Having found the difference between these two types of hot air engines, the next question is, which is the most desirable? It is generally understood that fuel is the greatest single factor in the cost involved in delivering power, and represents from 50 per cent

* Paper read before the New York Electrical Society and published in its Transactions.

in small plants to 60 per cent in large plants of that cost as has been determined by actual operation. In gas plants the fuel is only from 25 to 33 per cent of the cost of the power, but in order to bring out this point of efficiency most clearly, let us first develop it from the beginning by taking the theoretical view of the case, and having found out what this is, we can then see how far it is followed out in practice.

The unit representing the calorific values most used, when dealing with gas engines, gas producers, gases and fuel, is the British thermal unit, abbreviated to "B. T. U." A British thermal unit represents the quantity of heat required to raise the temperature of one pound of water 1 deg. F. at 39 deg. F. One B. T. U. equals 778 foot-pounds, and there are 2,564 B. T. U. contained in a horse-power. It will be seen that in considering the efficiency of a heat engine the temperatures involved are necessarily the governing factors. The theoretical efficiency of a perfect heat engine of any type is determined by the simple formula

$$\frac{T-T1}{T} = \text{Efficiency},$$

in which T is the acquired temperature from absolute zero, or the temperature of the power transmitting element at the time of expansion figured from absolute zero (which is 460 degrees below Fahrenheit's zero), and $T1$ the final absolute temperature after expansion. The difference between T and $T1$ is known as "The Temperature Range." The ratio that this temperature range bears to the total temperature taken from absolute zero is the percentage of thermal efficiency that the engine has. It will be seen that we work down to absolute zero. In Fig. 1 we have worked out practical cases, having assumed for the gas engine that the temperature of the gas mixture at explosion is 2,500 deg. above F. zero, which, when added to 460 deg. below that zero, gives a total absolute temperature for the explosion of 2,960 deg., which is the heat that the engine received. The exhaust has a temperature of 800 deg. F., which, when added to 460, gives 1,260 degs. This, when deducted from the original temperature of 2,960 degs., leaves 1,700 degs., as a credit to the engine, or an efficiency (thermal) of 57.5 per cent, provided the engine is a perfect translator of energy. Now for the steam engine. I choose to take the temperatures of the engine cited by Mr. Henry G. Stott in his paper before the American Institute of Electrical Engineers in January, 1906, because I desire to use them in the commercial comparison that I will make next. He assumes a temperature for the steam at point of admission of 367 degs. F., which when added to 460 degrees gives an absolute temperature of 827 degs., while the temperature of the exhaust is given as 100 deg. F., plus 460, or an absolute temperature of 560 deg. exhaust. Deducting this from the total temperature of 827 deg., we have for this steam engine a temperature range of 267 deg., which is 32.3 per cent of 827 deg., the total range, and 32.3 per cent in this case represents the thermal efficiency of the steam engine. It will be remembered we found the thermal efficiency of the gas engine to be 57.5 per cent. Some writers elect to put gas and steam engines on the same basis of comparison by assuming, for theoretical purposes, that they will both exhaust at atmospheric temperature, say 60 deg. F. On this assumption the steam engine will figure out a theoretical thermal efficiency of 37 per cent, and the gas engine, with an explosion temperature of 2,500 deg. F., a theoretical thermal efficiency of 82 per cent. But whether you take it on a theoretical assumption, or whether you use temperatures that may be expected in practice, it is plainly evident that the gas engine has a very much higher thermal efficiency than the steam engine, because the power-conveying medium can be eventually used at greatly higher temperatures. The foregoing assumptions as stated have been worked out on the principle that both the gas and steam engines were perfect devices for transforming or translating their useful temperature ranges entirely into useful work. Of course, in practice a proportion of this temperature that is represented by what I have called useful temperature range is used to overcome the friction of the engines, and is also lost in radiation, etc. Then again, in considering the over-all efficiency of a practical commercial plant as taken from the coal pile to the engine wheel, you must include the losses of piping, auxiliaries, boilers with stacks, or producers, as the case may be, and we find that in this respect the gas engine is again more efficient, because it has a commercial efficiency from coal pile to driving wheel of 20 per cent, while the very best steam practice in America as given by Mr. Stott is but 9.7 per cent, and in Europe is 8 per cent, and in Great Britain 7 per cent, as given by Mr. H. M. Hobart. Furthermore, the commercial efficiency which I have just given for the gas engine plant is obtained by even the small installations, while those given for the steam plants represent the very highest results that have so far been obtained from the largest and most economical central stations equipped with the very latest apparatus.

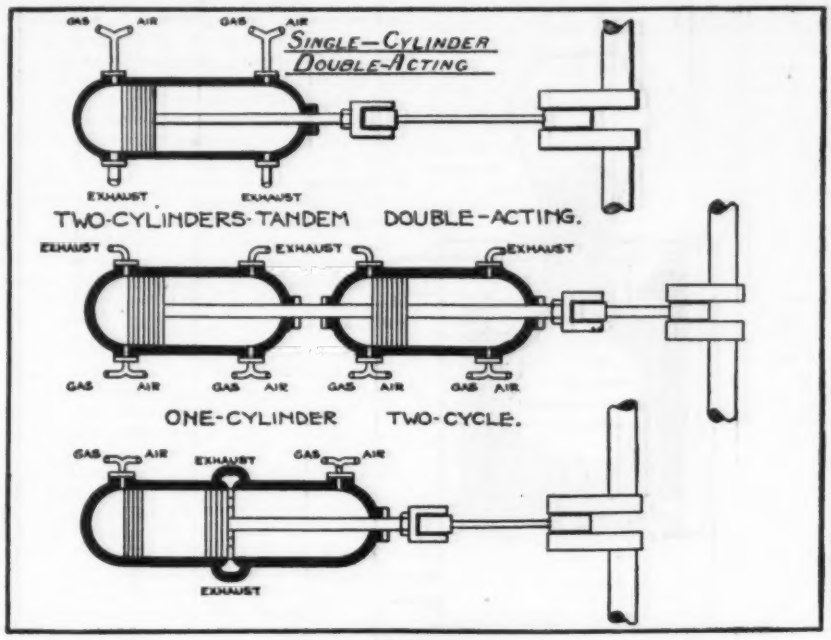


FIGURE 4

Having determined these commercial efficiencies, let us see just what differences in actual pounds of coal consumption they represent. This is easily done. We will divide 2,564 B. T. U., the theoretical quantity required to produce one effective horse-power, by the per cent efficiencies that we have just determined for each kind of engine respectively. We then find that the gas engine requires at 20 per cent 12,820 B. T. U. in order to supply one B. H. P., and there being 13,500 B. T. U. in an average pound of coal, we easily develop one B. H. P. at the engine from one pound of coal burned in the producer. With the steam engine, dividing 2,564 B. T. U. by 9.7 per cent efficiency, we must have 26,500 B. T. U. to get one B. H. P., so that the steam engine will require 2 pounds of coal burned in the boiler to develop one B. H. P.; at 8 per cent efficiency 2½ pounds; and 7 per cent 2¾ pounds of coal. These coal consumptions which we have cited represent the very highest engineering practice in their respective countries; other steam plant coal consumptions will run as high as nine and ten pounds of coal per B. H. P. in small central stations and industrial plants in which the installations are inefficiently installed and operated. With the gas plant not only is the apparatus itself inherently more efficient, but its operation is far more simple, and eliminates to a much greater degree the personal equation of the operators, so that one pound of coal per B. H. P. is easily attained in even the smallest gas plants against ten pounds of coal by steam plants of equal size. The cost of maintenance is less and the cost of operating large gas engines and producer plants is one-half that of steam plants, and where the gas is supplied from an outside source, such as natural gas, blast furnace gas, etc., the labor is only one-third that of a steam plant of corresponding capacity. As concerns repairs, it is possible that for the engines they may now be slightly higher, due to the newness of the art, but with a producer plant and its auxiliaries repairs are far lower than in the corresponding departments of a steam plant, so that the total repairs are less. As concerns overload capacity, a characteristic feature of the gas engine is that its maximum capacity is reached when taking its maximum charge of gas and air combined in the right mixture, and exploded at just the right time. This means, that if the commercial rating of the engine is set 15 per cent below this most economical point, it is not possible to carry more than 15 per cent overload without slowing down the engine. This condition can be easily met in several ways: By installing additional gas engine capacity, by running in connection with the gas engines a steam turbine which readily takes up the load changes, or by a storage battery. The additional saving in total cost of power accomplished by the gas engine should be sufficient to more than offset the expenditure necessary to take care of this overload factor. If it is not, then the case is not a good one for gas engines.

As to the first cost, this is very difficult to state exactly because the conditions vary so largely; but it is, possibly, safe to assume that the complete gas plant, including producers, will cost say 20 per cent more than a corresponding steam plant, and with coal at $2.50 a ton, it is not difficult to earn a handsome return on this additional investment. Important factors are therefore (*a*) the cost of coal, (*b*) the number of hours a day that the plant is run, (*c*) the load factor of the plant, i. e., the percentage of its average load to its rated load. The higher these values, the more is it to the advantage of the gas engine plant.

The gas engine itself is very simple, and its working parts are easily understood, and adjusted by the operators in charge, once they have become familiar with the running conditions. The engine may consist of one or more cylinders, in which the gases are burned at initial pressures of about 300 pounds per square inch, the gas being admitted at atmospheric pressures and compressed to about 100 or 120 pounds, the resulting mean effective pressure after explosion ranging from 60 to 75 pounds. Piston speeds run about 600 to 850 feet per minute.

Gas engines are divided into four general classes: as concerns cylinders, single acting and double acting; and four cycle and two cycle, as concerns explosions. Gas engines are built vertically with one, two, or three cylinders, where the weights of the pistons and length of crankshafts permit, and horizontally, with one cylinder, two cylinders *vis-à-vis*, or tandem, and four cylinders, *vis-à-vis* or tandem in the larger sizes.

In a single-acting engine the explosion takes place at only one end of the cylinder; with the double-acting engine, the explosions take place at both ends of the cylinder.

When we speak of a four-cycle engine, we mean

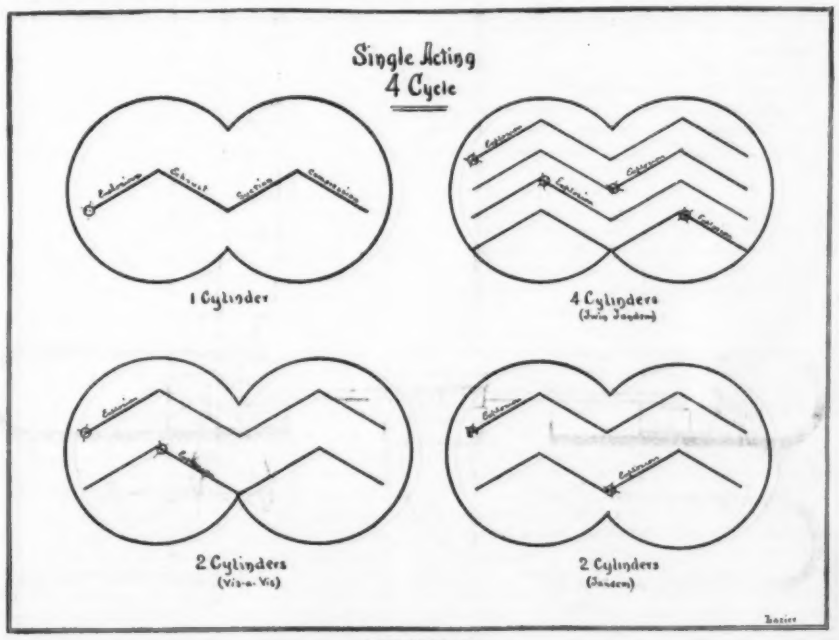


FIGURE 5
EXPLOSIONS PER STROKE PER REVOLUTION

that four strokes of the piston are taken to complete the cycle from one explosion to the next. The first stroke, called the "suction" or "charging stroke," sucks in the charge. The return of that stroke, called the "compression," compresses it. At the beginning of the third stroke, or "power stroke," the charge of gas is exploded, and on the fourth, or "exhaust" (sometimes called "scavenging stroke"), the cylinder is scavenged of the products of combustion. The four-cycle movement is called the "Otto" cycle or "Beau de Rochas."

With the two-cycle engine the charging stroke and the scavenging stroke are eliminated, the piston's duty being performed by a subsidiary means external to the engine, and either attached to it, or operated as an independent auxiliary.

As concerns the working parts of the engine, it is provided with a governor, operated on the same general principles as a steam engine governor, and with about the same degree of regulation.

The valves of a four-cycle engine consist of the following: First: Gas and air valves, which determine the proportions of gas and air that are to enter into the mixture. These are simple cocks, placed in the gas and air mains, with dials, showing the extent they are open, and are only changed at the will of the engineer. Second: The hit-and-miss cut-off valve, which admits the amount of gas determined by the gas valve into the mixing chamber, unless the governor of the engine makes it lose a cycle. The hit-and-miss regulation is only used below one-quarter load with close governing engines. Third: The cut-off valve with its inlet valve. This cut-off either varies throughout the stroke the opening through which the gas mixture enters the cylinder, or else acts as a straight throttling valve, by maintaining a fixed opening during charging stroke. In either case it is adjusted by the governor to suit the load. Its inlet valve closes the port as soon as the charge has been admitted. Fourth: The exhaust valve, which because of the high temperature of the exhaust is water cooled. I might say that the mixing chamber, which is a simple pocket, is located between the hit-and-miss valve and the cut-off valve. Now these four valves are of the simplest type and require but little engineering skill to keep in repair. They are positively opened against springs by cams or eccentrics carried on a side shaft, geared to the engine's crankshaft. These cams and eccentrics are so set as to perform their respective operations at the proper time. This side shaft also operates the igniters. Ignition is obtained in two ways: one by bringing a small portion of the main gas charge in contact with a red-hot tube operating as a Bunsen burner, or preferably by means of a "fat" electrical spark, the latter having survived the former in this country. This spark is either of the make-and-break type or is a jump-spark. The terminals in either case protrude directly into the clearance of the engine cylinder, which contains the gas. Modern practice tends to double ignition plugs so as to always have one as a standby. The current for supplying the spark can be obtained from vibrating magnetos placed across each spark point, or from revolving magnetos or small generators, or from primary or storage batteries, preferably the latter, but a standby source should always be available. I should like to point out the importance of always having an independent relay or standby source of current entirely independent of the main source.

The time of ignition can be adjusted at will, but it is generally set to take place just when the engine piston reaches the highest point of compression.

Gases are compressed before exploding in order to increase their efficiency. The molecules when pressed tightly together operate with greater force on explosion in the same manner that burning gunpowder becomes effective when it is confined in the gun barrel. Compressing the gas generates heat, and the hydrogen in the gas burns at low temperatures, so that the pressure to which any gas can be compressed is limited by the amount of hydrogen that that gas contains, and it is interesting to know that while the gas may be rich in B. T. U., it may not be as efficient as a leaner gas with less hydrogen, which can be worked at a higher compression.

Gas engines cannot start with a full load, and require a clutch where such load is say more than one-quarter of their capacity, although I have seen an 865-horse-power engine start and reach full speed with a load of 300 horse-power in less than forty seconds. Of course, when driving electric generators it is necessary only to open the switch. Starting is obtained by applying compressed air to the engine at about 100 to 120 pounds pressure, or by motoring the generator which it drives. There are two elements that enter into gas engine operation which are not found in steam engines; one is that when running, a charge of gas may fail to ignite, and will enter the exhaust unburnt; there it is just possible that it will come in contact with particles of incandescent carbon and explode; this explosion is called a "back-fire." Then again a charge may enter the cylinder and because it is richer than the adjustment of the compression provides for, the heat resulting from that compression may prematurely fire it, or there may be particles of incandescent carbon in the cylinders that will fire it. This is called a "premature." The result of either one of these two actions is not in any way serious, and only momentarily tends to slow the engine down. Engines properly cared for may run for days without having an occurrence of either kind.

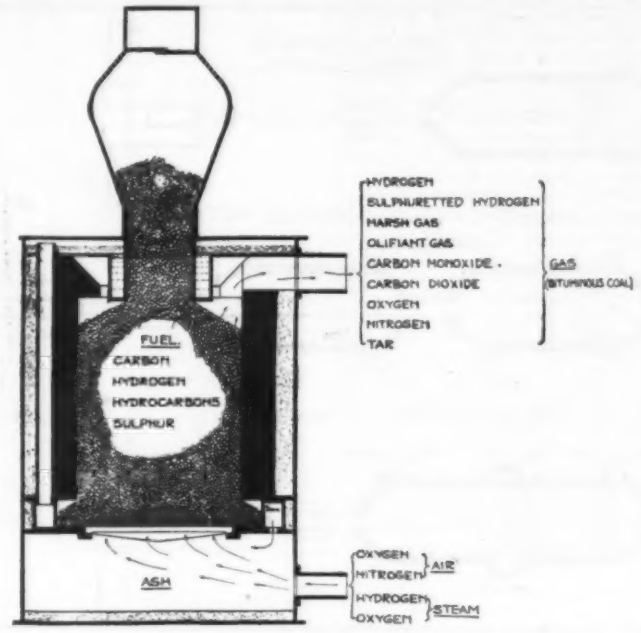


FIGURE 7

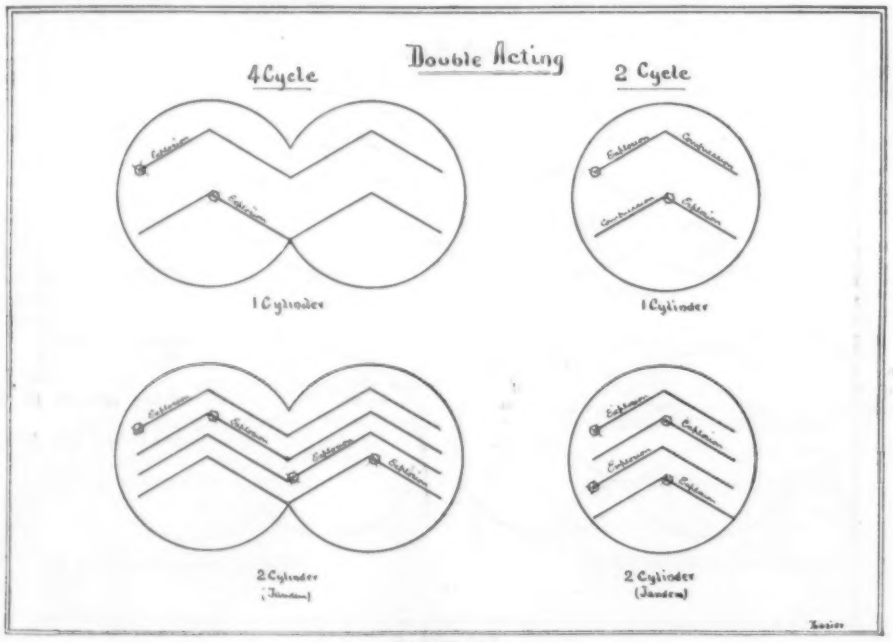


FIGURE 8
EXPLOSIONS PER STROKE PER REVOLUTION

Indicator cards are taken in identically the same manner as with steam engines, and are figured in identically the same way. Eccentricities in the cards, however, have not the same significance as the steam engine cards, nor it it so easy to trace their origin.

Now as concerns gas turbines. At first glance these appear to have the same advantages over the reciprocating engine that the steam turbines have. There are, however, two very serious obstacles first to be overcome if the gases in the turbines are to be direct acting. The first is that the thin blades of the turbine are not able to stand the high temperatures of combustion, which would run about 2,500 deg. F. The other factor in the problem and of most serious consideration is that it is not possible to get compression before igniting the gas, and as we have pointed out, this compression is necessary to the efficiency of the engine. It might appear from what I have just said that the turbine with a secondary expansion chamber will be the direction in which we can look for developments along this line, although nothing promises in this direction at this time, and the engineers are fully occupied in developing the reciprocating gas engine, which already approximates the performance of the best reciprocating steam engine, and which they hope to improve still further, because of the simplicity of the principles involved.

So much for the engine.

(To be continued.)

CONTEMPORARY ELECTRICAL SCIENCE.*

CALIBRATION OF GOLD-LEAF ELECTROMETERS.—The gold-leaf electroscope is being widely employed in measurements of ionization. It is calibrated by applying known potentials to it. But H. W. Schmidt points out that it is not as a rule used for measuring differences of potential, but for measuring currents by noting the variation of the potential. To obtain the best results, therefore, another principle of calibration should be employed. The relative difference of potential between two scale divisions may be obtained by exposure to the β and γ rays of a radium preparation fused into the glass wall, and noting the times taken by the leaf to traverse successive divisions. If there is a saturation current, these times are proportional to the differences of potential. If the shape of the electroscope leaves a doubt as to whether there is a saturation current, it is only necessary to connect the electroscope with an air condenser which is not too small, and to expose this alone to the radium rays. The author believes that with a well-calibrated leaf electrometer as good results may be obtained as with a quadrant electrometer. It has besides the great advantages of simplicity, small capacity, and independence of external electric disturbances.—H. W. Schmidt, Physikalische Zeitschrift, March 1, 1906.

RECOMBINATION OF SALT IONS.—G. Moreau has determined the coefficient a in the equation

$$dn/dt = -an^2,$$

which expresses the manner in which the recombination of ionized salt vapors depends upon the number n of ions present in the unit of volume. The method employed was the same as that employed by Townsend for gases ionized by Röntgen rays. Determinations were made at two different temperatures, 80 and 15 deg. The comparative recombination coefficients were 415 and 78 for potassium iodide, 410 and 10.6 for chloride, and 421 and 0.84 for bromide. The ratio of recombinations to collisions was found to range 56 per cent for potassium chloride at 80 deg. to 99 per cent for potassium bromide at 15 deg. The mobility of these vapor ions is smaller than that of ordinary gaseous ions. The average proportion of recombinations at 80 deg. is two-thirds, whereas at lower temperatures it often happens that every collision results in a recombination. This is due to the great mass of the ions, which are positive atoms surrounded by several layers of neutral atoms, thus approaching the constitution of the heavy ions produced by phosphorus, which might perhaps be called charged droplets rather than ions.—G. Moreau, Comptes Rendus, February 12, 1906.

ORIGIN OF TERRESTRIAL MAGNETISM.—A. Pflüger discusses the interpretation of terrestrial magnetism as

* Compiled by E. E. Fournier d'Albe in the Electrician.

derived from the rotation of a charged ellipsoid. He points out that the magnetic field must be discoverable at the surface even when the magnetic instrument rotates with the ellipsoid. Bucherer has rigidly proved that the ponderomotor force on a magnet at rest is the same as that on a magnet rotating with the earth. Hence the equations determining the magnetic moment of a revolving electron also apply to the magnetic moment of the earth. The charge of the earth is unknown, but a rough idea of it may be obtained from the potential gradient above the ground. According to Exner, it would appear to be about 2.4×10^{17} electrostatic units of negative electricity (giving a potential of nearly a billion volts), or about the same charge as that of the sun, only of opposite sign. The rotation of this charge in the direction of the actual rotation of the earth would produce a magnetic field approximately the same in direction as the observed field, but about 10,000 times weaker than the actual field. If a positive charge is supposed to be located in the upper regions of the atmosphere, and is allowed for in the calculations, the agreement is not much better. It must, therefore, be concluded that the rotation of the earth's charge is not the only cause producing its magnetic properties.—A. Pflüger, Physikalische Zeitschrift, March 1, 1906.

POLONIUM RAYS.—Thomson and Rutherford suspected that polonium rays, although they produce a positive charge by their impact, do not consist of purely positive particles, and Rutherford estimated that for every four α-particles emitted one electron was also emitted by polonium, thus reducing their apparent positive charge. Soddy also supposed that both positive and negative corpuscles are generated by the impact upon the gas of neutral particles, which alone, he maintained, are emitted by the polonium. In order to test these questions P. Ewers has adopted a new apparatus, consisting of a copper disk coated with polonium and surmounted by a nest of small copper boxes serving as diaphragms, and enabling the observer to control the path of the particles shot out from the polonium. The boxes had such dimensions that no particle could reach the upper plate unless it were projected at an angle of at least 55 degrees to the lower plate. By employing magnetic and electric fields of different strengths he was enabled to prove that the negative particles are the slowly-moving electrons discovered by J. J. Thomson. He does not agree with Soddy and Bragg that the positive charges are acquired by collision, since higher potential gradients fail to increase the ionization of the residual gas.—P. Ewers, Physikalische Zeitschrift, March 1, 1906.

CANAL RAYS.—By an ingenious experimental contrivance C. Füchtbauer has been enabled to prove that canal rays impinging upon metals cause them to emit electrons, and that some metals reflect the canal rays to a very perceptible extent. Behind the perforated cathode he mounted a circular diaphragm consisting of six sectors, five of them covered with various metals and the sixth open. The diaphragm could be turned by means of a magnetic contrivance, and was so arranged that each sector could in turn be brought to face the canal-ray tube. But for a small aperture, the diaphragm was completely inclosed in a metallic cylinder, which could be earthed. When the open sector was presented to the canal rays they penetrated into the cylinder and gave up their charges to it. But on interposing one of the metallic sectors the canal rays were reflected, and they and the electrons issued from the cylinder. By deflecting the electrons the two constituents could be estimated separately. The author found that at high voltages (30,000) all metals give off electrons, in the same order as Volta's series. Platinum gives off least, and aluminium gives off four electrons for each canal-ray particle it receives. Platinum, silver, and copper reflect 10 per cent of the incident canal rays, even at the highest voltages.—C. Füchtbauer, Physikalische Zeitschrift, March 1, 1906.

POLARIZATION BY ALTERNATING CURRENTS.—P. G. Gundry has made some researches calculated to throw light on the action of an electrolytic coherer, whose resistance is increased by the impact of electric waves, or diminished when the electrolyte, like phosphoric acid, diminishes in resistance with increase of temperature. The experiments consisted essentially in sending an alternating current of frequency varying between 80 and 5,000 $\sim$ per second through an electrolyte between two mercury electrodes, one of which was very small, while the other was more than 1,000 times as large, so that the latter was unpolarizable in comparison with the former. The results show that a perfectly symmetrical alternating current acting at a polarizable electrode leads, according to the osmotic theory of polarization, to an asymmetry of the polarization—in other words to a direct current. The case of a mercury electrode being worked out gives as a result that the direct current I satisfies the relation

$$\frac{NI}{i_0^2} = \text{const.},$$

where N is the frequency and $i_0 \sin 2\pi Nt$ is the alternating current. The direction of the current corresponds with an effective diminution of the concentration in the neighborhood of the electrode. The same relation should hold when the electrode is a solution of a complex salt, provided that diffusion from and to the layer of electrolyte surrounding the electrode plays the important part in the polarization. In the electrolytic coherer it may be supposed that some reaction such as $H_2 = 2H$ is reached with finite velocity, whereupon the relation I/i_0^2 holds good, and is independent of the frequency.—P. G. Gundry, Philosophical Magazine, March, 1906.

ENGINEERING NOTES.

The Egyptian government has completed the arrangements for the construction of the new barrage across the Nile at Esneh, in upper Egypt, and the work is to be carried out by Sir John Aird & Company, who were responsible for the construction of the Aswan and Assiut barrages. The completion of this work will be of great benefit to agriculture in this region, since extensive tracts of what is now barren and waste desert land will be brought under irrigation. The barrage will only regulate the level of water at high Nile when, as it is at present, it is too low to supply the necessary water for the land both above and below the point at which the work is to be carried out. The sluices, lock gates, and swing bridge in connection with the scheme have been intrusted to the same firm that carried out this part of the work in the two other barrages. There will be 120 sluices, and they will be of an entirely new design. The work is to be completed in four years.

In the years 1896 and 1906, the average tractive power for each class of locomotive was as follows:

	1896.	1906.
For freight engines	13,900	31,500
For passenger engines	12,200	22,900
For switching engines	14,700	26,800
For all engines	13,700	28,700
Total number of engines, all classes	551	764

During the period of evolution represented by the foregoing figures, new difficulties arose; new problems required solution. In the desire for adequate boiler capacity within the limits of dimensions and weights imposed, errors were made in boiler design, in restricting the depth of the fire-box, in the spacing of the flues, and in the use of abnormal grate areas. With the greater use of cast steel, advantage was taken to reduce weights of details, to the extent of contributing the weight thus saved to further increase the boiler dimensions. In some cases, such as wheel centers and frames, the lightness of the parts did not always result in failures, but their weakness contributed to the rapid wear, or failure of other dependent parts, and in other cases, failure of the parts themselves.

Owing to the increasing number of railroad accidents in America and Great Britain, the causes of many of which have never been ascertained, the administration of the German state railroads has decided to carry out a series of interesting and realistic experiments for the purposes of discovering possible means of preventing a number of such calamities. For the purposes of these researches a certain section of the Berlin-Zossen military railroad, measuring about 1¼ miles in length, is to be utilized, and the tests will be carried out by the state engineers, assisted by the military officials. Upon this section it is intended to cause artificial railroad wrecks from the various causes contributing to such disasters, such as misplaced switches, spreading rails, defective tires and axles to the wheels, while the track will be strewn with various objects capable of causing derailments. Derailments are a prominent feature of German railroad working, and although they are invariably of a trifling character, yet they cost the state some $1,250,000 per annum. In the course of these experiments it is intended to test the Gericke-Bollman apparatus, which has recently been devised for the prevention of derailments. The device comprises a type of railguard catches, which when the wheels of a locomotive or coach leave the rail from some cause or other come automatically into operation and guide them back to their proper position.

The British Admiralty have made an important decision in regard to all torpedo craft, which are in future to burn oil fuel exclusively. In the new vessels of this type no accommodation whatever will be provided for the stowage of coal. By this means not only will there be effected a great economy in weight and space, but it is anticipated that greater speed and a larger radius of action will be possible, with an accompanying relief to the manual exertion and fatigue on the part of stokers. This decision has been made as the result of the remarkable steaming records set up by the battleships of the "King Edward VII." class during the recent maneuvers. These vessels, in addition to the bunker supply of 2,000 tons of coal, were supplied with 450 tons of oil stowed in the double bottoms and in tanks. The boilers were of the Babcock & Wilcox water-tube type. During the maneuvers these ships covered 4,000 miles at an average speed of 18 knots, though for three hours a speed slightly exceeding 20 knots was attained, the current being favorable. In view of the fact that the designed speed of these battleships is 18.5 knots, the increased speed attained on this occasion is attributed to the utilization of liquid fuel, since during this period of three hours oil was consumed exclusively, as the coal supplies had been exhausted. With the oil fuel these vessels were able to out-distance vessels of higher designed speed. Actual experience also has demonstrated the fallacy of the laboratory experiments in connection with the relative steam-producing value of the best steam coal and liquid fuel, which is given as four to three, but which practice shows to be as two to one. If greater proportions of oil are consumed the reason has been found to be due to either faulty draft or defective burners. The speed developed by the vessels burning liquid fuel during the maneuvers, which was much in excess of that hitherto attained with coal, has aroused considerable interest in naval engineering circles, and with the new burning apparatus that had been evolved by the admiralty experts during their prolonged experiments with oil, the numerous disadvantages formerly encountered have been successfully overcome.

SCIENCE NOTES.

To the disputed question of the vitality of dried or buried seeds a new contribution has been made by M. Fliche, a French botanist. In the Forest of Hane some years ago he was astonished to find large quantities of a plant called cypress-spurge, or wolf's milk, in blossom. It is a plant well known in Italy, but not indigenous to France. Two years later the plants entirely disappeared. Similarly another growth, in another clearing in the forest, was unearthed, and this in its turn flourished and disappeared. The obvious botanical reason for the disappearance of a plant is that it is choked in the struggle for life by the existence or overgrowth of other plants better suited by the environment; and that the cypress-spurge, not finding itself able to cope with its surroundings, disappeared.

The British Museum has recently been presented with an exceptionally fine specimen of stone carving of great archæological and artistic value. This is a Roman urn or ash chest dating from about the end of the first century of the Christian era. The exterior of the sarcophagus is most lavishly decorated in relief carving with festoons of fruit, rams' heads, and rosettes, and is one of the finest specimens of decoration of the period ever unearthed. The translated inscription runs: "To the sacred Manes, Flavia Tysche, aged twenty years. Alexander dedicates to a most fruitful and well-beloved wife." The inscription on this urn is recorded in the Corpus Inscriptionum Latinorum. The urn itself, however, which once reposed in the Villa Negroni, had long been lost sight of until it chanced to be rediscovered by a well-known English archæologist in the Capel Cure collection at Badger Hall, near Wolverhampton.

Artificial Pumice Stone.—While emery serves for polishing tools, sand for polishing stones and glass, ferric oxide for fine glassware, and lime and felt for metals, pumice stone is more frequently utilized for the polishing of softer substances. Natural pumice stone scarcely has the constancy or the hardness desired, and therefore efforts have been made to replace the natural with an artificial product. The Schumacher works at Hietigheim, in Germany, have produced an artificial pumice stone with sandstone and clay, which has been applied to numerous purposes, as the water-proofing of leather and clothing and production of felt and stucco for sculptors, the polishing of wood before painting, and for lithographic stones and other objects. The artificial products are used in the same manner as the volcanic products. For producing a smooth surface on wood, the operation is conducted dry; but for finishing, the product is diluted with oil. For fine work an article of fine grain is provided; and for coarse work, an article of coarser grain.—Drogisten Zeitung.

New Process for the Production of Citric Acid.—M. J. Ohly proposes in the Journal de Pharmacie a new process for the production of calcium citrate with calcareous juices based on the fact that when a concentrated solution of calcic chloride is gradually added to a solution of sodium citrate the precipitate produced is redissolved, but forms by agitation a magma, which becomes crystalline on the application of heat. The process is conducted in the following manner: 50 cubic centimeters of concentrated lemon juice containing about 56 per cent of citric acid are diluted with 100 cubic centimeters of water and left to stand over night; the albuminoid matters deposited are filtered, and the filtrate is mixed with the necessary quantity, or a slight excess, of calcium chloride in concentrated solution. The mixture is afterward neutralized with a solution of caustic acid, stirred up well, and the pasty substance washed into a filter with hot water, to separate the sodium chloride formed, and the calcium chloride in excess. The residual calcium citrate is deposited hot with the calculated quantity of sulphuric acid of density 1.7, the calcium sulphate filtered, the filtrate heated for a new precipitation of the calcium sulphate dissolved and finally decolored with bone-black, previously freed from the phosphates contained therein. The citric acid is separated by crystallization. The author claims that this process is more simple and economical than the old method. The yield is nearly theoretic, and the product is of superior quality.

It is now pretty generally recognized that Newton's "laws of motion," including his definition of "force," are not unalterable laws of thought, but merely arbitrary postulates assumed for the purpose of interpreting natural phenomena in the most simple and adequate manner. Unfortunately, nature is not very simple. "As the eye of the night-owl is to the light of the sun, so is our mind to the most common phenomena of nature," says Aristotle. And if since Newton's time we have made some progress in the knowledge of physics it is but reasonable to conclude that the postulates which appeared most simple and adequate two hundred years ago can not be regarded as such at the present time. This does not mean, of course, that the mechanics of Newton has lost its value. The case is somewhat parallel to that of the postulates of geometry. Just as the abandonment of one or the other of the postulates of Euclidean geometry leads to a more general geometry which contains the old geometry as a particular, or limiting, case, so the abandonment or generalization of some of the postulates of the older mechanics must lead to a more general mechanics. The creation of such a generalized

mechanics is a task for the immediate future. It is perhaps too early to say at present what form this new non-Newtonian mechanics will ultimately assume. Generalization is always possible in a variety of ways. In the present case, the object should be to arrive at a mechanics, on the one hand sufficiently general for the electron theory, on the other such as to include the Newtonian mechanics as a special case.

TRADE NOTES AND FORMULÆ.

Formula for Glazing.—Rasp 12 parts of white Marseilles soap and melt with 30 parts of white carnauba wax; pour in 20 parts of pulverized chalk, stirring constantly until the mixture is cooled.—Science Pratique.

Polishing Paste.—Melt together 2 parts of paraffine and 6 parts of lubricating oil; then mingle with 8 parts of infusorial earth 1 part of oleic acid, and a few drops of oil of mirbane are to be added.

Borax for Soldering.—Prepare by heating the borax in a metallic receiver until it has lost its water of crystallization; then mix with calcined kitchen salt and potash in the proportion of 8 parts of the first and 3 parts of the two others. Grind the whole fine in a mortar.

Mixture for Polishing Hard Metals.—Mingle 80 parts of infusorial earth, 30 parts of tin oxide, 300 parts of pipe clay, and 3 parts of tartaric acid. Also, 28 parts of infusorial earth, 10 parts of pipe clay, 3 parts of hyposulphite of soda, and 2 parts of ferric oxide may be used.

Another receipt for surfaces not quite as hard or for fine polishing consists of a mixture of 3 parts of sub-carbonate of iron and 1 part of rottenstone. The necessary vehicle is lard oil in sufficient quantity.

Aluminium for Bottle Closures.—W. Dafert and K. Kornauth report in the Chemiker Zeitung on the use of aluminium for closing bottles. According to the tests conducted by J. Schuch the aluminium stoppers examined by him consisted practically of technically pure metal. With these he instituted experiments with a view to ascertaining to what extent they are subject to attack by wine or wine vinegar. There was a decrease of weight in one week averaging 1 milligramme, hence a very insignificant one. Nor does the wine suffer any change through contact with the aluminium stoppers.

Powder for Silvering Copper and Brass.—This may also be used with success for some other metals. It is composed of 12 parts of potassium cyanide, 6 parts of silver nitrate and 30 parts of calcined carbonate; the whole is mingled and kept in a well-stoppered bottle. It is scarcely necessary to say that two of these ingredients are dangerous to handle, and that the dust of the cyanide is very dangerous if breathed into the lungs. The liquid is applied to the metal by rubbing energetically, without touching the bare skin with the powder. The metal is afterward rinsed with fresh water, dried and polished.

Hardening Substance for Glass-working Tools.—Melt 100 parts of rosin, yellow prussiate of potash 300 parts, blue vitriol 100 parts, and linseed oil 100 parts, boiling down the mass to about 1,000 parts. Upon hardening it forms a solid body. The tool is brought to a cherry red and pushed one to three times into the mass, whereupon it is heated repeatedly to cherry-red and cooled in cold water. If it is desired to harden small gimlets or other tools to a very high degree so as to be able to drill hard steel a tempering in mercury is recommended. When this is not available good results are obtained by inserting the working point into a white onion, thus hardening it.

Recovery of Tin from Sheet-Tin Waste.—M. Neil has recently made known in France a new process for recovering by electrolysis the tin used in cans and other old sheet-tin. The waste is treated with a boiling solution of ferric chloride. This solution is afterward submitted to electrolysis, with a cathode of tin and an anode of graphite. The tin is deposited at the cathode, and the chlorine set free at the anode enriches the solution. The electric current employed has an intensity of 500 amperes and a tension of 25 volts. The density of current should reach 60 amperes per square centimeter of electrode. This process permits of extracting about 9 kilogrammes (18 pounds) of tin from a ton of sheet-tin waste.

Determination of the Hardness of Water.—Herr W. Peters recommends in German periodicals the following operative method for waters which are charged with magnesium salts in addition to calcareous salts, as is the case with river waters connected with potassium chloride works. He measures 100 cubic centimeters of the water to be tested, adds a few drops of a solution of alizarine and titrates at the boiling point with a tenth-normal solution of chlorhydric acid until a yellowish red coloration appears, which persists even after prolonged boiling. On multiplying the number of cubic centimeters of the acid employed by 2.8 the temporary hardness is obtained in German hydrotimetric degrees. The water thus neutralized receives the addition of an excess of a tenth-normal solution of soda and an equal volume of a tenth-normal solution of sodium carbonate boiled for a few minutes, cooled to 15 deg. and increased to 500 cubic centimeters. 100 cubic centimeters are filtered and the alkali in excess treated with a tenth-normal solution of chlorhydric acid, making use of methyl orange as indicators. By multiplying the number of cubic centimeters of the soda utilized, brought to a total volume of 200 cubic centimeters, by 2.8 the total hardness is obtained in German hydrotimetric degrees.

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